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MACHINE DESIGN

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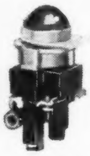

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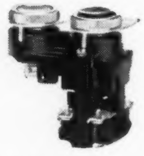
Latch-Safe Switch



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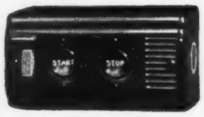

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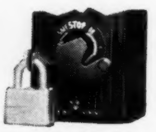

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C-H

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

Volume 15 APRIL, 1943 Number 4

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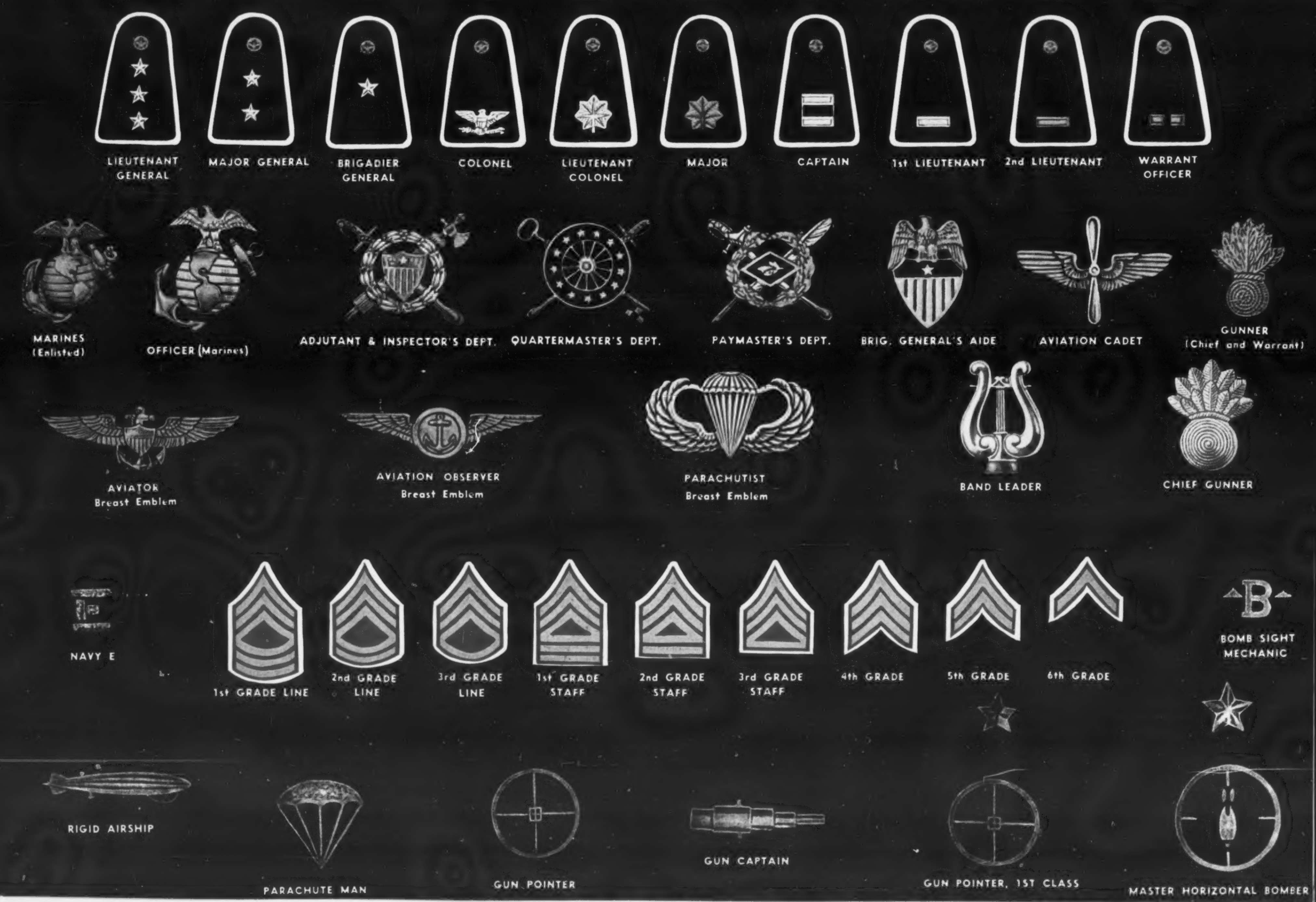

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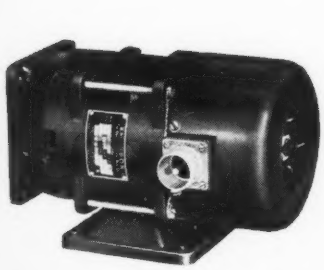

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Topics

GROUND recording of aircraft flight test data has been developed by Vultee to record as many as seventy different instrument readings. In this way data may be analyzed carefully during flight. Radio communication with the pilot facilitates directing the test and also provides a means to warn the pilot of excessive stresses in a maneuver or of the failure of a mechanism which otherwise might go unnoticed, resulting in a crash.

♦

RUBBER from the Russian dandelion, kok-sagnyz, which has been planted in New Jersey will add to our supply of this vital material. The Soviet Union has 100,000 acres under cultivation, yielding 125 pounds per acre. Synthetic rubber that is now being produced from soybeans and ethyl alcohol is expected to reach 2000 tons a month.

♦

INFRARED lamps are proving useful for drying inked lines on mechanical drawings in less than one minute, saving draftsman's time and eliminating the possibility of smeared lines.

♦

DIRECT-CURRENT fans for the Navy have been developed by Westinghouse which use 34 per cent less steel, 30 per cent less copper, 80 per cent less brass and 50 per cent less nickel alloy resistance wire than previous designs. Through reduction in weight these savings greatly simplify shockproof mountings.

♦

STEEL saved by the upset method of shell production in two plants of American Forge is equivalent to 800 medium tanks and alone would keep the plants operating six months.

♦

ICE-TIRES laced with steel coils have been developed by Goodrich for airplanes to reduce skidding on airport runways. Parallel rows of the steel coils are so embedded in the tread during vulcanization that the edges grip on ice and snow.

♦

PLASTIC-GLASS windshields for airplanes, utilizing glass and polyvinyl resin, offer high protection to pilots. Panels having reasonable weight and optical characteristics will stop fifteen-pound bird carcasses traveling at speeds in excess of 200 miles per hour. Half-inch plastic sheet laminated between ⅛-inch semitempered glass forms the impact-resisting panel of the assembly. This panel is separated from a front panel of tempered Herculite glass by a narrow air space, through which is circulated hot air for de-icing. The circulation of hot air also maintains the temperature of the windshield at that required to maintain maximum strength. If impact on the front element exceeds the strength of this windshield, developed by the Pittsburgh Plate Glass Co. and plastic manufacturers, the glass shatters and falls away, leaving the rear element which will withstand the reduced impact and prevent the object from entering the cockpit.

♦

POWERFUL searchlight has been designed for operation on twenty-four volts. Because arcs are normally unstable at less than fifty-four volts, a new type of carbon electrode together with a new control scheme was developed for the application.

♦

LOW TEMPERATURES of 92 degrees below zero Fahr. can be obtained in a new three-room icebox. Twelve-inch walls of sheet metal, air-space insulated, reduce heat transmission to a minimum. Windows consist of seven sections of tempered glass, also air insulated.

♦

HEAT TREATMENT of malleable iron castings, through a process invented by Frank G. Buffum, is said to convert the castings to metal having the characteristics of hardened steel.

♦

FOR EMERGENCY use on aircraft and other military equipment carbon dioxide cylinders may be connected to hydraulic systems that have been damaged by anti-aircraft or machine-gun fire. In this way, limited power may be restored to such parts as bomb-bay doors, landing gears, brakes, etc.

♦

OUR WAR PRODUCTION effort is now entering a phase in which technological improvements must play a major role. According to Donald M. Nelson, "our production of war goods must be expanded greatly during 1943 . . . . For a large part of the increase in production, we must rely on our ability to find ways to make more with what we have."

How Test Unit Simulates Flight Conditions

By Victor Blasutta
Chief Engineer
Denison Engineering Co.

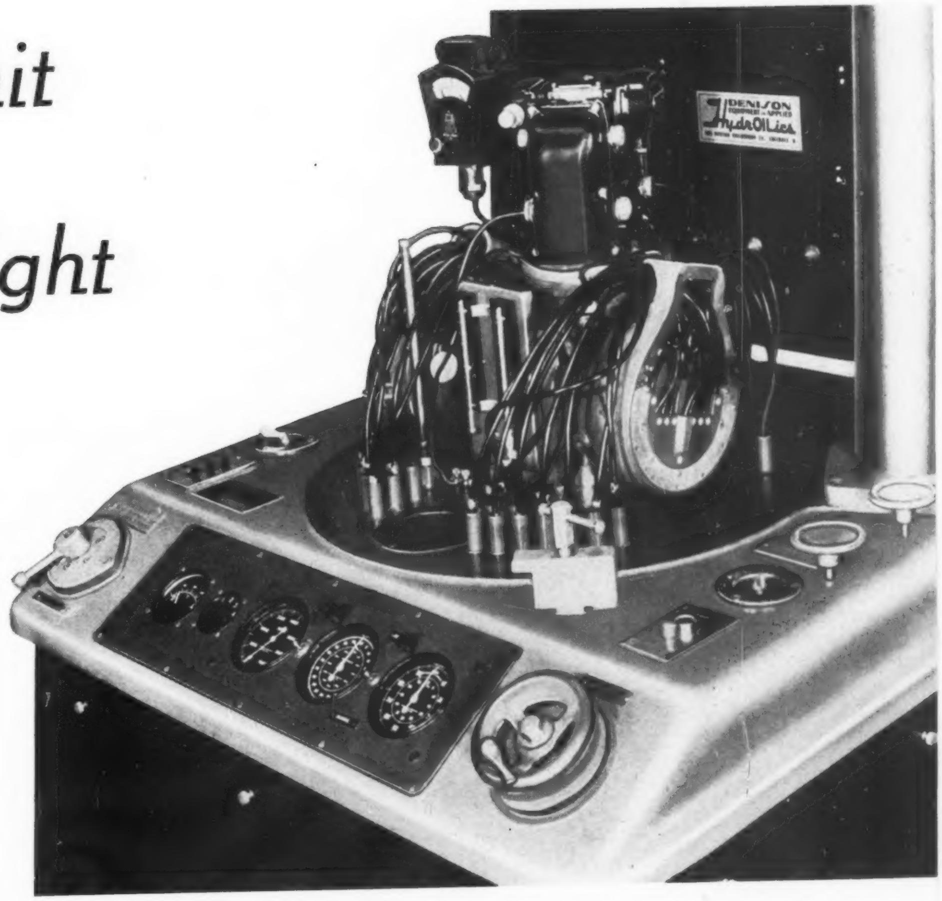


Fig. 1—Panel board and table of magneto test stand showing magneto assembled prior to test. Hygrometer enables observation of humidity

AIRCRAFT magnetos must be tested under conditions of temperature, humidity and atmospheric pressure similar to those encountered in flight. In addition to providing these conditions, the magneto test stand which is the subject of this article has gone far toward improving and speeding up test and inspection procedure. The design was developed by the engineering department and research laboratories of the Denison Engineering company with the cooperation of one of the large manufacturers of magnetos.

A magneto is placed on the machine, as shown in *Fig.* 1, and a large bell jar assembly lowered over it and clamped airtight, *Fig.* 2. From then on the operator has only to manipulate external controls during the whole test. Although at this time the method of testing the magneto itself cannot be divulged, the methods of controlling temperature, humidity, air pressure and circulation of air, as well as the design of the drives for the magneto gearbox, can be discussed.

AIR CIRCULATION AND TEMPERATURE CONTROL: Air is circulated within the bell jar by means of a blower powered by an electric motor, for uniform distribution of heat and humid air. Heat is obtained from an electrical heating element mounted inside the blower assembly directly in the path of the outlet air flow and controlled automatically through a thermostat. The bulb of the thermostat extends upward about twelve inches and is plainly visible in *Fig.*

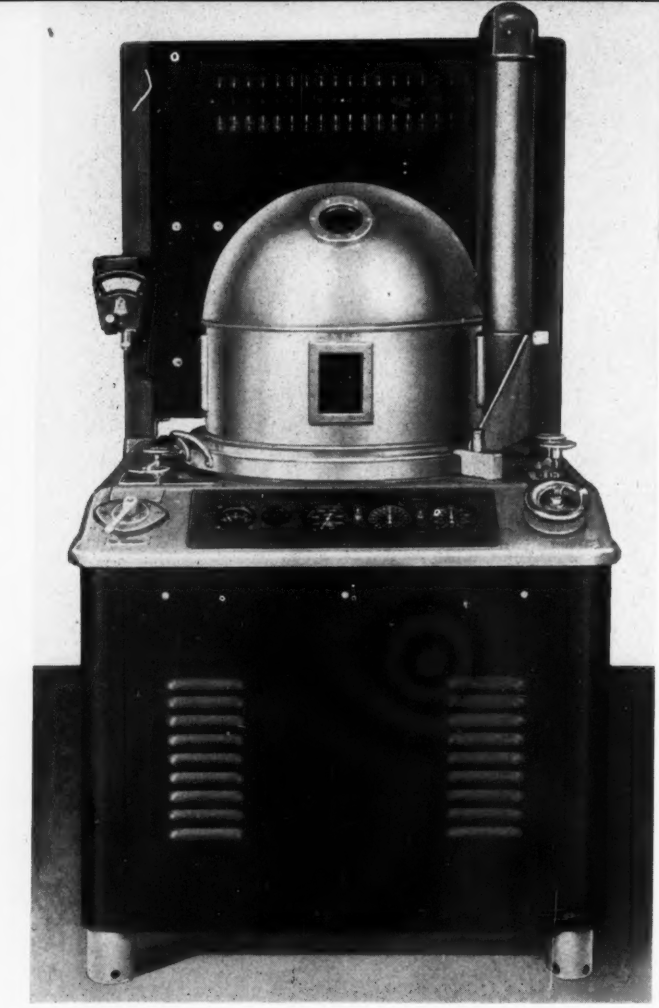


Fig. 2—Left—Front view of test stand with bell jar in place for altitude tests. Temperature controller is mounted at left of back panel

1. Any predetermined test temperature from room temperature to 220 degrees Fahr. may be obtained.

Control of Humidity: Steam was found to be the best method of humidifying the air, this being accomplished by piping a steam line to the body of the centrifugal blower. Amount of moisture in the air under the bell jar during tests may be varied by the amount of steam let into the blower assembly, steam flow being controlled by a needle valve on the table.

Control of Vacuum: For simulating the low pressures existing at high altitude a vacuum pump assembly powered by a 3-horsepower electric motor is used. Suction line of this pump is connected to the top of the blower assembly. The pump is capable of pulling a maximum vacuum of 29 inches of mercury inside the bell jar. Amount of vacuum desired, ranging between atmospheric pressure and maximum vacuum available, is controlled by adjusting the pet-cock on the lower rim of the bell jar and permitting air to enter.

Blower Design Problems: A problem to be overcome in the design was air leakage into the blower, because during certain periods of operation this whole assembly is subjected to a vacuum of 28½ inches of mercury. The problem was readily overcome for the blower itself, although sealing the drive shaft for the fan presented more difficulty. Leather, plastic or a lubricated type of seal could not be used in this location because at times the air and the blower attain a temperature of approximately 220 degrees Fahr. Different types of metal seals were first tried but these had to be discarded due to the high temperatures. A carbon seal which withstands high temperature satisfactorily even under dry conditions was finally selected.

Vacuum Seal Resists Temperature

Problems of the Terminal Sleeve: Terminal sleeves for electrical connections through the table had to have high insulating properties, and also be capable of withstanding the atmospheric pressure tending to force the sleeves inside the bell jar assembly. The first design was not successful because, under the extreme heat of 220 degrees Fahr. in the bell jar, the sealing compound around the terminal sleeves softened and consequently the sleeves were blown into the bell jar. The holes through the table were then sealed by means of an "O" ring, a taper on the sleeve itself, a rubber washer on the underside and a nut to tighten the whole assembly. After the first few of these were made the tests proved successful but later, in actual production, flaws caused by the machining of the material became apparent. This was overcome by having the terminal sleeves and the nuts for them molded rather than machined.

Hydraulic Control of Gearbox Speed: The upper gearbox for driving the magneto is mounted on the table of the test stand, *Fig.* 4. It is driven by a shaft that passes

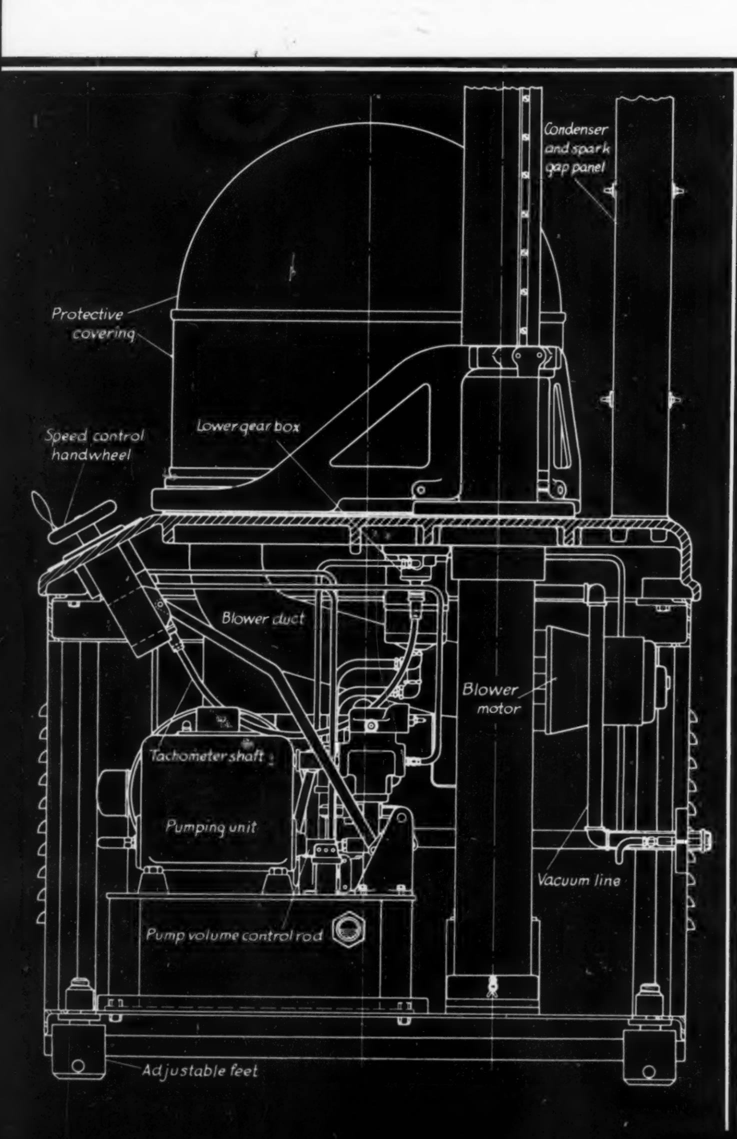


Fig. 3—Left—Side elevation with panel removed shows linkage for speed control, also pumping unit blower, duct and tachometer drive

up through the table from the lower gearbox. On top of the upper box is mounted the magneto to be tested. Distributors are mounted on the right and left sides of the gearbox. The horizontal shaft that drives the two distributors is driven through spiral gears of correct ratio by the vertical shaft which drives the magneto. Gearbox speed is controlled by a handwheel mounted on the right-hand side of the table panel. This remote control directly operates the hydraulic pump volume which in turn controls the speed of the fluid driving motor. The volume control on the pump has a horizontal slide movement. To be able to control this movement from the panel, the problem was to convert the hydraulic slide movement into an angular rotary movement emitting from the panel, *Fig.* 3. To convert the horizontal slide movement to an angular movement, levers are used, and to convert the angular slide movement back to an angular rotary movement, a threaded rod is employed.

Indicating and Control Units

On the front center of the table panel is mounted a chrono-tachometer assembly. At the left is an electrical temperature indicator controlled by the switch just to the right of it. This switch has four leads coming up through the table which are connected to various parts under the bell jar. By turning the switch to any one of the leads, the temperature at that particular lead terminal is indicated on the thermometer. The first dial is a direct-reading tachometer indicating the rate per minute at which the magneto is turning over. The second dial of the tachometer setup is a revolution counter; one revolution of the needle on the dial indicates that the magneto has turned 100 revolutions. The third dial, which is the dial at the extreme right, is the time counter, the face of which is subdivided into one hundred parts. One revolution of the needle on this dial indicates the elapsed time of one minute. The revolution counter and the time counter can be automatically run together in such a manner that they may be simultaneously started and, after exactly one minute, stopped and a reading taken. This time counter is used at extremely low speeds because the direct-reading tachometer is not easily deciphered for speeds lower than 500 revolutions per minute.

Slinger and Felt Seal Solve Leakage Problem

Upper Gearbox Design: Trouble encountered with this gearbox during tests consisted mainly of maintaining lubrication seals. When the bell jar was under vacuum, oil would ooze out through the seals on the vertical and horizontal shafts, *Fig.* 5. Metal seals were first tried because it was known that leather or composition seals could not stand the heat of 220 degrees Fahr. nor the high surface speeds to which they were being subjected. The first few gearboxes released had what was thought to be an improved design of metal seal, the first laboratory test seeming to prove that the seal would hold up. However, field tests showed that after about one hundred hours of operation the seals started leaking oil at a temperature of about 150 degrees Fahr. and a vacuum of 28 inches of mercury. The next step was to try different types of oils, but that didn't seem to solve the problem at all. Oil slingers were

Fig. 4—View of stand partially assembled shows upper gear box and rig for supporting bell jar

then tried, starting with a slinger on the top seal of the vertical shaft. On the first test this did not solve the problem but it cured about 80 per cent of it and by using a felt type seal and the slinger, leakage of oil at the top of the vertical shaft, *Fig.* 5, was stopped. This seal held up under temperatures of 220 degrees Fahr. and a vacuum of 28 inches of mercury. After a hundred-hour test with no leakage on that seal the design of the seals on the horizontal shaft was changed with a view to correcting the trouble there. Success did not come so quickly on the horizontal shaft, because the large gear dipped in the lubricating oil and at high speeds it carried the oil up the walls of the casting and in turn the oil would flow down the back side toward the bearings and seals, thus flooding the seals with oil on the inside. This made it difficult, at high temperatures and speeds, to keep the oil from seeping out.

At this point it should be mentioned that the aim was to achieve an absolutely dry gearbox on the outside. It was not even permissible to have an oil film on the outside of the case, because if such an oil film formed, it would tend to creep up into the distributors and possibly into the

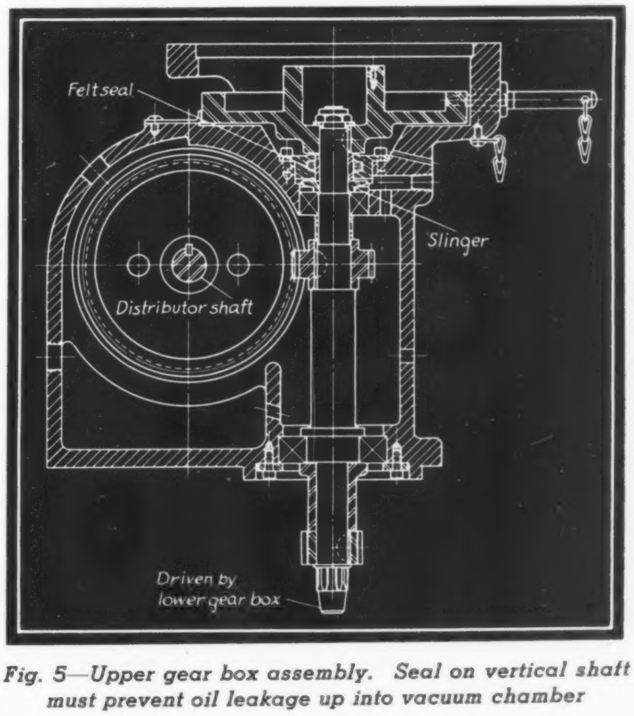


Fig. 5—Upper gear box assembly. Seal on vertical shaft must prevent oil leakage up into vacuum chamber

magneto or down over the table on which all the high-tension cables were mounted. When this occured, it would short-circuit most of the lines that were connected to the spark gaps. Therefore, when speaking of sealing at high temperatures and speeds we speak of an absolute 100 per cent seal.

Control of the flow of oil caused by the large spiral gear dipping in the oil was next undertaken. After many try-outs the gear was encased in a housing inside the gearbox, in which there was one large hole through which the spiral gear was driven by a vertical shaft. Several small holes were drilled in the bottom of this housing to let enough oil seep in for lubrication. By this method the gear did not disturb the oil in the reservoir, yet picked up enough oil to lubricate itself. The bearings were lubricated through small holes from the reservoir. Finally, with slingers and felt seals on the horizontal and vertical shafts and by encasing the large gear in a housing, a perfectly sealed gearbox was achieved. Final test was run over a period of five hundred hours of continuous heat at temperatures of 200 to 220 degrees Fahr., a constant vacuum of 26 to 28½ inches of mercury, and a speed of 6000 revolutions per minute on the vertical drive shaft. At the end of the five-hundred-hour test the gearbox was examined and was found perfectly dry on the outside. When later taken apart and inspected, all bearing surfaces and other wearing parts such as ball bearings and gear teeth were in perfect condition and well lubricated. Immediately after the test the gearbox was redesigned to accommodate these changes.

Lower Gearbox Design: The lower gearbox, *Fig.* 6, is mounted on the underside of the table. From it is driven the upper gearbox which in turn drives the magneto and distributors. It is also geared to the tachometer drive. The source of power for the gearbox is the fluid motor. In the original design of this machine, leakage oil from the fluid motor was used to lubricate the upper gearbox. This produced a stream of oil about half the diameter of the lead of a pencil. The oil entered the upper gearbox, lubricating all its moving parts and flowing back into the lower gearbox, whence it drained off to the reservoir. But there was one fallacy in this whole setup. When the bell jar and gearbox were under vacuum the original seals did not hold very well, causing a partial vacuum in the upper gearbox—enough to suck oil from the lower gearbox which in turn sucked oil through the drain connection from the oil reservoir of the hydraulic system. Twenty minutes after the first trials of this method were started, there was more oil in the gearbox than at the beginning. After a few trials the source was found. Then and there the method of lubricating the gearbox was changed and a stagnant oilbath type lubricating system adopted.

In the original design the fluid motor drove the tachometer shaft at one-to-one ratio and the upper gearbox shaft at two and a half times motor speed. After the first machine was completed and run through its preliminary tests, it was found that a speed slower than 75 revolutions per minute on the magneto could not be obtained without rotary pulsations caused by the cam on the magneto. To maintain original speeds and also go down to a lower speed and direct-couple the fluid motor to the drive shaft, it was necessary to redesign the lower gearbox. *Fig.* 6 shows this new design. A gearshift arrangement permits either a one-to-one ratio or the two and a half-to-one ratio. The shifter is designed with a long rod which extends from the left side of the machine. By pulling out or pushing in this handle, shifting of the clutch in the gearbox is accomplished. It is designed with two spring-type detents so that the clutch will not start in a half-way position, these detents holding the clutch either in one-to-one ratio posi-

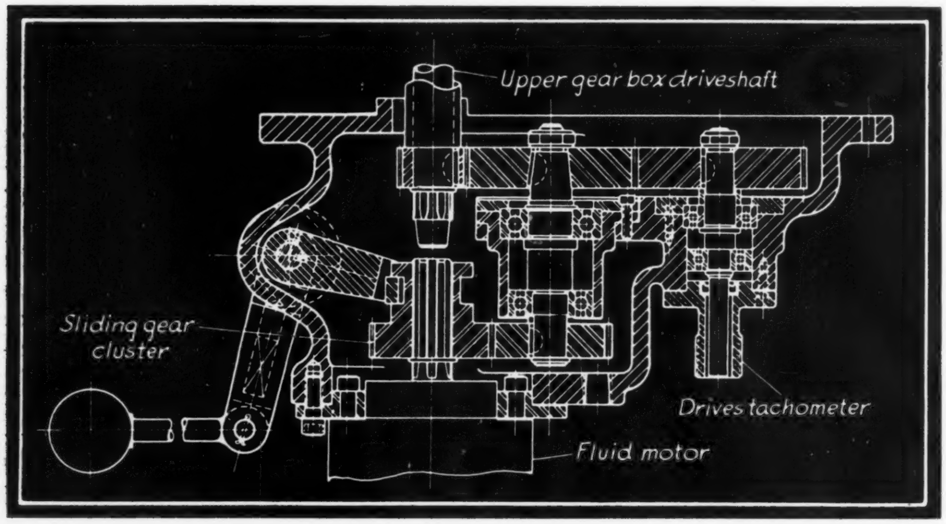
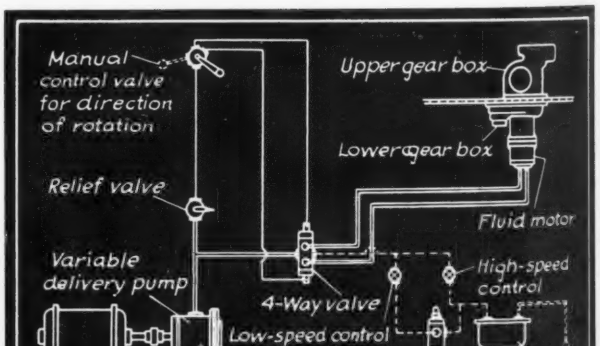


Fig. 6—Left—Lower gear box provides two speed ratios for magneto drive, direct for low speed, increasing for high

Fig. 7 — Below — Hydraulic circuit for magneto drive, permitting infinitely variable speed adjustment from 12 to 7000 revolutions per minute



tion or two and a half-to-one ratio position. After the first gearbox of the later design was built, assembled and put to test, only 50 revolutions per minute could be reached without pulsations. Upon further investigation it was found that too much clearance was allowed in the spline. By reducing the backlash the speed could be dropped to fifteen revolutions per minute without pulsations. It was extremely important to eliminate pulsations in the magneto drive-

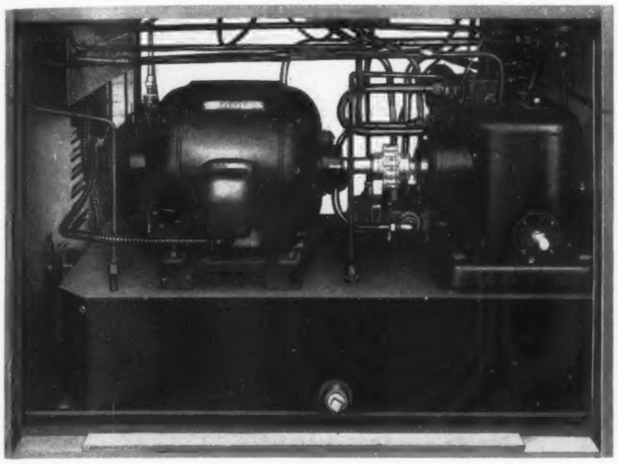


Fig. 8—View with front panel removed showing motor and variable volume hydraulic pump

shaft, otherwise the time at which the gaps made contact could not be accurately established.

Hydraulic Circuit: The upper and lower gearboxes which drive the magneto and distributors are driven by a fluid motor, speed being controlled through the hydraulic circuit. Speed of the fluid motor ranges from 5 to 2800 revolutions per minute. Through the gearboxes it drives the magneto from 12 to 7000 revolutions per minute. A three-horsepower motor is used as a power source, driving a variable volume axial piston type hydraulic pump, *Fig.* 8. The circuit, *Fig.* 7, consists simply of a pressure line running from the pump to a four-way valve, which controls the direction of rotation of the fluid motor. This valve is pilot-operated by a small rotary valve mounted on the left end of the table panel board. A relief valve protects the system from excessive pressure. Oil returns from the fluid motor through the four-way valve, passes through a pressure relief valve and from there into a cooler before it returns to the oil reservoir.

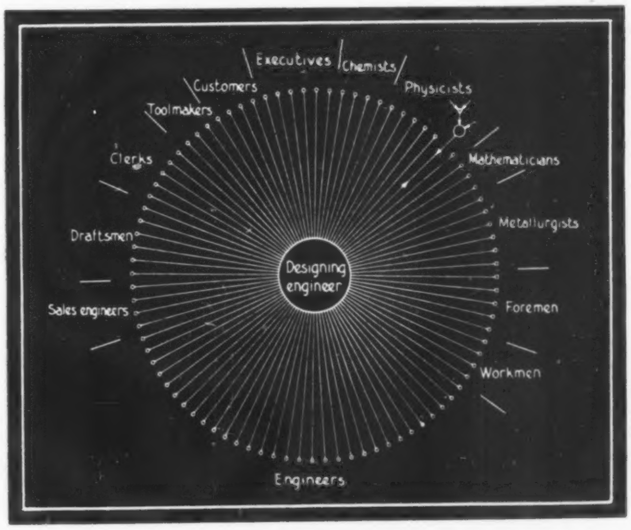
Back Pressure Prevents Coasting

Because of the compactness of the unit, the size of the oil reservoir had to be kept to a minimum, therefore an oil cooler was installed to dissipate the heat energy from the returning oil. The pressure relief valve installed between the four-way valve and cooler has the function of carrying a definite amount of back pressure on the fluid motor. Purpose of this is to prevent the fluid motor coasting forward under the impulse of the cams of the magneto when running at the lower speeds. Two hand valves are installed and mounted on the right-hand side of the table panel of the machine. One valve, if open, by-passes the above-mentioned relief valve when the fluid motor is operating at high speed. The other hand valve is for the purpose of throttling the oil returning from the four-way valve to the pressure relief valve and is used at extremely low speeds only.

Bell Jar Assembly: The bell jar was originally made of blown glass. This design was later changed to an aluminum bell jar with four glass port holes. Safety was the reason for the change in materials. A little thought had to be put into the method of controlling the bell jar because of its weight. It had to be mounted in such a manner that it could be easily and quickly unclamped and moved out of the way. This was done by having a tube rise out of the table, in which a counterweight balances the bell jar, *Fig.* 4. Incidentally, the aluminum bell jar, besides being safer, weighed less. The bell jar is fitted over a cast aluminum ring attached to but free to slide on the tube rising out of the table. The ring is keyed to the tube in such a manner that when the bell jar assembly is lifted to its maximum height it may be revolved away from the work about 180 degrees. The part of the cast ring that fits around the steel tube does not actually have metal-to-metal contact with the tube. Actual contact is made by four rollers, cutting friction to a minimum. The weight a man has to lift on the bell jar in raising it is only approximately five pounds.

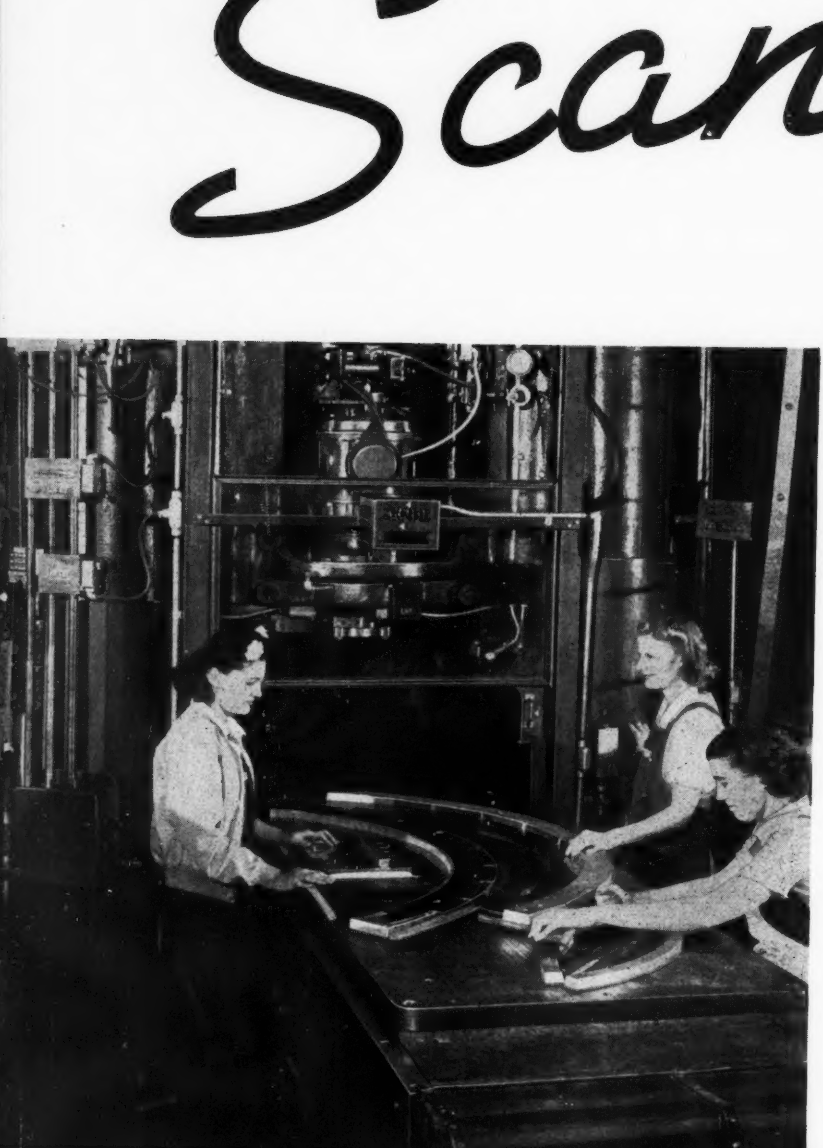
Collective Effort Aids Designer

COLLECTIVE effort usually far excels that of any single individual, as indicated by the example of a new type of equipment recently designed by the General Electric company. Ninety persons were either profitably consulted or were actually engaged in the development



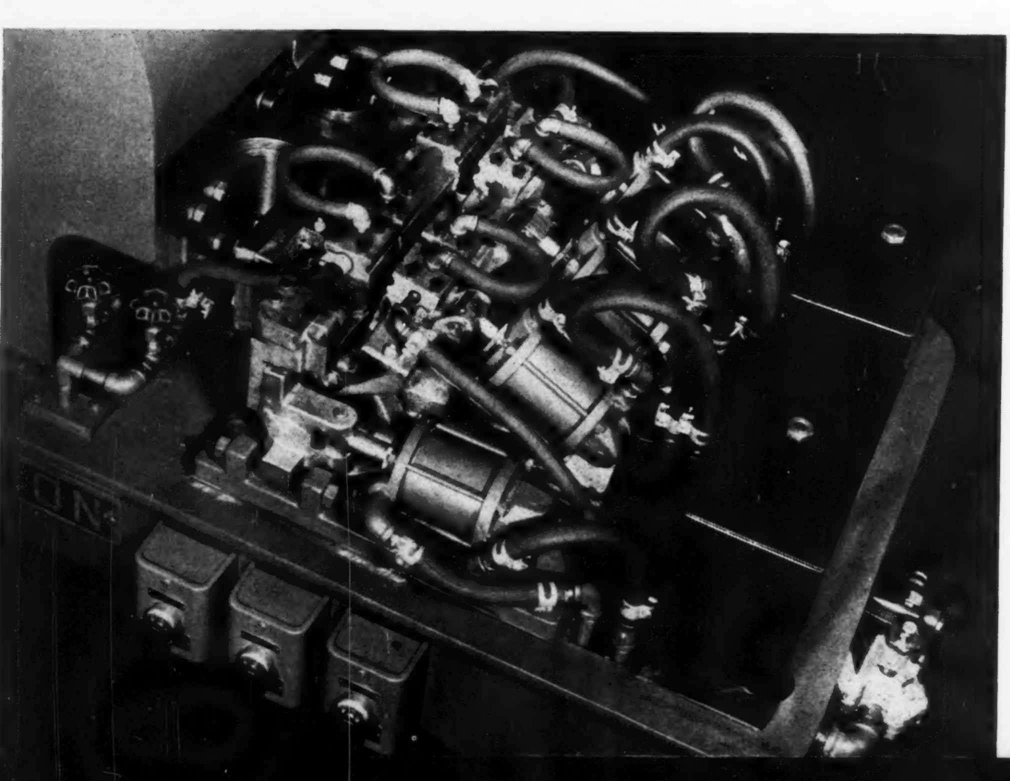
of items for the project. Their grouping by occupation is shown in the diagram, each line corresponding to an individual contributer. Contributions were made either at the invitation of the design engineer or on the initiative of the individual or group. Time devoted by each man varied from a few minutes—just enough to suggest the key idea of a solution—to many months of steady effort.

Scanning the field for IDEAS



FULLY automatic operation of press at left permits employment of inexperienced operators with little training. A six-die slide hydraulic machine with interlock control, this Bliss press is incapable of improper operation, thus reducing danger of accidents to a minimum. Pushbuttons with independent control of pressure at each station together with interlocking features obviate necessity for a master station and its operator.

Ease of moving heavy slides into and out of press obviates laborious work in locating die slides or rearranging work within the press.



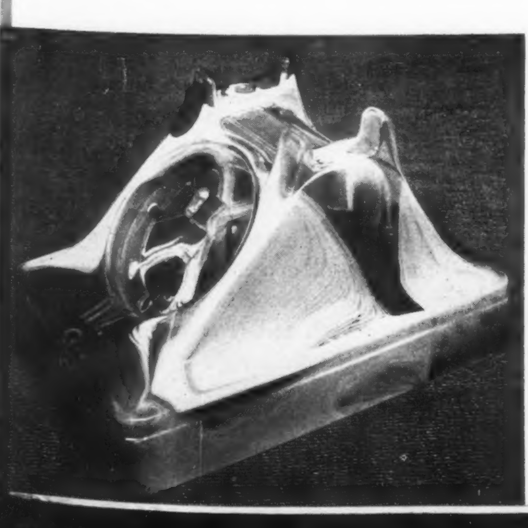
Electrical resistance of a part, together with pneumatic cylinders, is utilized in bending machine at left. Designed by Thomson-Gibb, heating and bending cycle is automatic, being preset for the particular operation performed. Operator control is confined to three pushbuttons on front of machine. One

closes the dies, one starts the automatic cycle and the other releases the part.

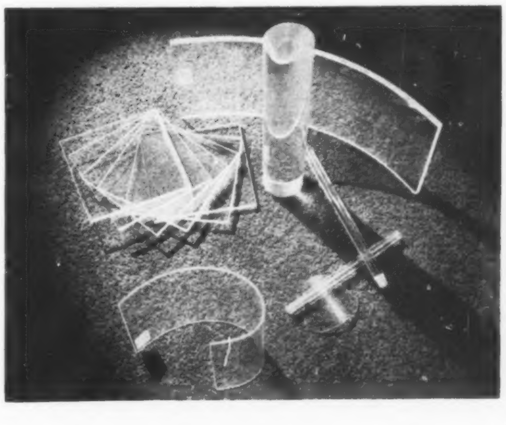
Mirrors perform the trick of measuring hot steel plates in a system devised by Westinghouse Research Laboratories for controlling at a glance the width of armor plate in a new steel mill where it is impossible to use conventional methods of measuring. Shown at right is a model arrangement of the system consisting of mirrors, a pane of glass, lights and properly spaced lines. One set of mirrors is arranged to catch an image of the glowing steel, with a second set aimed at the spaced lines. Both images are directed into a mirror so that the lines are superimposed on the image of the steel plate. In this way visual control is facilitated and the mill rolls are kept adjusted for the proper width of plate being rolled.

Safety switch, above right, utilizes the principle of a pendulum to function as an impact-initiated control. Developed by the Walter Kidde organization as an automatic "fireman" for aircraft, the pendulum operates an electric switch when subjected to sudden acceleration or deceleration from any direction through 360 degrees in a given plane, which plane is normally horizontal. The switch controls the release of carbon dioxide into the engine compartment. Operation of the device may be adjusted to suit specific conditions.

Flow of plastic material in a molding die is graphically illustrated in the telephone housing, shown below. The model was produced by the Bell Laboratories through the use of a clear molding compound with a few white-pigmented granules. Under heat and pressure the charge becomes plastic as it flows into the dies and each pigmented particle leaves a streak, indicating its course through the mold much as a drop of ink makes a trace in running water. Utilizing this method it is possible to check design and molding technique or to determine causes for flaws, improperly filled cavities, etc.



High resistance to abrasion ten to thirty times greater than that of clear commercial plastics has been developed in an experimental plastic material by the Pittsburgh Plate Glass Co. Called C.R. 39, the plastic is thermosetting and may be molded or laminated under extremely low pressures, releasing no gaseous or liquid by-products when curing. None of the common solvents are capable of dissolving it. Large flat sheets or intricate three-dimensional shapes may be molded with almost equal ease. Shape is retained even when exposed to high atmospheric temperatures. Some of the shapes are shown below.



Wartime Drives and Controls

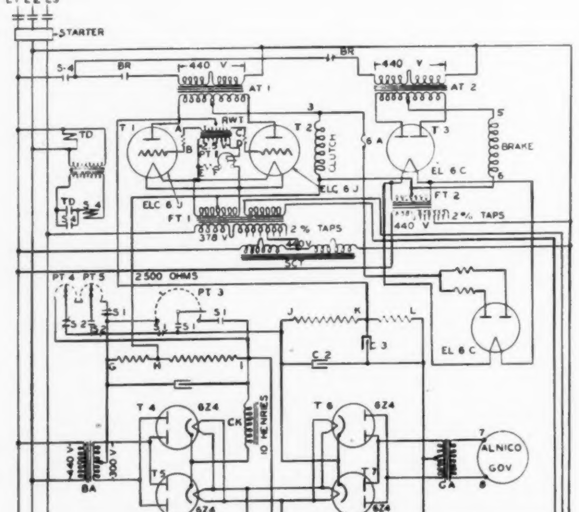
MATERIAL conservation, increased production schedules, reliability in performance, operation by unskilled workers, are some of the major problems facing designers. The necessity, under current conditions, for accomplishing more with fewer facilities makes a careful analysis of all designs imperative. Drives and controls, being the heart of all machines, demand special attention. The accompanying articles on this phase of design are presented because solutions to problems met in specific designs often plant the seeds of other solutions in widely different types of machines

Eddy-Current Drive Improves Operation

By N. E. Wenzel

Asst. Chief Engineer, Globe Steel Tubes Co.

INTEGRAL combination of a squirrel-cage induction motor and an electronically-controlled eddy-current clutch and eddy-current brake provides a satisfactory answer to the problem of driving tube draw benches. Desirable features for a draw bench drive include preset maximum and minimum chain speeds, smooth load starting, constant limit or controlled torque acceleration, electric braking and wide continuous speed range with good regulation.



Such a drive has, in brief, the following operating cycle: With the draw chain running at a low, preset hooking speed, the plier hook is automatically engaged when the plier carriage returns to the die block. Simultaneously, the plier jaws grip the tube point which protrudes through the drawing die.

The speed of the draw chain is immediately accelerated to a preset maximum speed in the shortest possible time that the nature of the material to be drawn permits. When the tube clears the die and has been removed from the bench, the operation of the plier retriever motor initiates the simultaneous operation of the eddy-current brake, and also de-energizes the clutch. The brake is energized until the draw chain decelerates to its preset hooking speed. Return of the plier carriage to the die block completes the cycle.

In the eddy-current drive unit the motor rotor is not keyed to the output shaft of the unit but rather to a quill shaft. The opposite end of the quill shaft carries a field-drum which revolves at basically synchronous speed for all draw chain speeds. The poles of the field spider together with its exciting coil are arranged inside the field drum. This field spider is keyed to the output shaft of the unit. Also keyed to the output shaft is the eddy-current brake drum. An electric governor-generator completes the unit.

The conversion of the constant speed of the motor to a constant torque with variable speed is made between the poles of the magnetic field spider and the constant-speed drum.

Grid-controlled, gas-filled, rectifier tubes T_1 and T_2 in the diagram provide excitation for the clutch coil. Tube T_3 excites the brake coil. With the selector switch on automatic, both the

high and low chain speeds are preset by adjusting potentiometers PT_1 and PT_5. This adjustment sets a basic reference voltage on the grids of tubes T_1 and T_2. Governing of the speeds results from the voltage generated by the governor-generator. This voltage is proportional to the output-shaft speed of the machine. When the governor voltage increases sufficiently to reverse the reference grid voltage on tubes T_1 and T_2 the tube firing stops, clutch excitation ceases, and clutch and governor speeds decrease until the governor voltage loses its control of the tube grids. Alternate firing of the tubes by the reference voltage and cutting off by the rising governor voltage accomplishes the governing function. Speed regulation of about 2 per cent over the rated speed range results from this method of control.

Smooth starting and controlled-torque acceleration feature the drive. Since the torque effect is of magnetic origin the load cannot be started until, with fixed excitation, there is sufficient slip to create the required torque. This means exceptionally smooth starting, a decided asset in a draw bench drive.

Fast acceleration results from using a torque-control arrangement in the electronic control. This utilizes for acceleration the maximum torque output of the motor. Torque is permitted to rise to about 200 per cent of full-load rating, but no higher during acceleration. The cyclic nature of tube drawing permits this practice without exceeding the continuous heat rating of the motor.

A current transformer CT connected in one leg of the motor provides a voltage for rectifier tubes T_8 and T_9 directly proportional to the torque output of the drive unit. When this voltage exceeds the maximum set by resistor R, it overcomes the opposing reference voltage on tubes T_1 and T_2 and shuts them off. Resulting deceleration of the clutch, along with coincidental decrease of motor-line current, permits the tube to fire again. Thus torque limiting is accomplished in the same smooth manner as the governing function previously discussed.

Eddy-current braking reduces chain speed to the preset hooking speed after a tube has been drawn. Control relays in the electronic unit transfer excitation from the clutch coil to the brake coil by disconnecting transformer AT_1 from the line and connecting transformer AT_2.

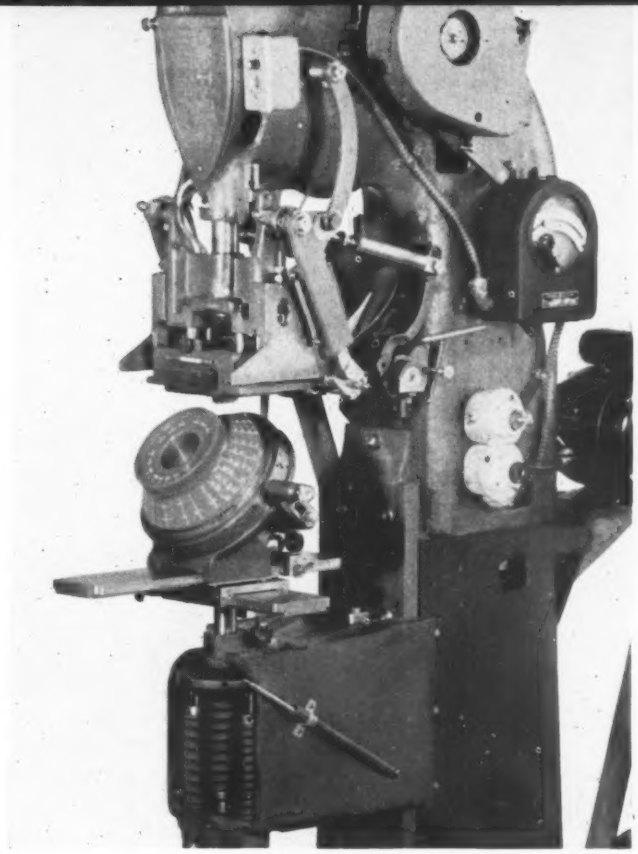
Speed of the clutch drive is continuously variable over a 5:1 speed range with close regulation. Greater speed variation is possible for short intervals at a sacrifice in regulation.

This electronically controlled unit provides a tube draw bench drive with all of the desirable design features demanded by best current practice.

Provides Cycle and Temperature Control

By David Putnam
Markem Machine Co.

MARKING plastics with indented-colored letters for nameplates involves accurate control of temperature and time of cycle as well as proper indexing and pressure. These features are embodied in the marking machine illustrated and are automatic. The thermostat used in controlling the heat of the head which accomplishes



the simultaneous indentation and coloring, whether it be used on nameplates, terminal strips, or molded objects is mounted directly in the head of the machine closely adjacent to a thousand-watt electric heating element which it controls. Mounted on the front of the die block is a thermometer which is used only as a means of determining when the machine has reached the proper operating temperature, the thermostat controlling the heat during the rest of the operating day without necessity of further reference to the thermometer.

Another interesting application of electric control to this equipment is the time clock which is used to control electrically the period during which the electrically-heated, thermostatically-controlled hardened and ground steel printing die is held against the object being indented and colored. This controls the length of the dwell through the use of a microswitch whose circuit is closed when the foot treadle is depressed, a half revolution mechanical clutch and a solenoid whose circuit is opened when the time clock has counted out the proper time cycle. The time cycles used on this equipment vary from one to fifteen seconds, and the clock is calibrated by seconds to afford this range.

Coloring is accomplished simultaneously with the indentation and is made possible by marking compounds produced for use with this equipment. They are especially compounded so that the heat, pressure, and time dwell exerted by the printing head fuse the compound to the plastic as an integral part of the indentation process. The machine is especially designed to allow rapid change of the printing elements and the work-holding fixtures which support the object. This permits desired detail to be applied to plastic objects after the parts have been molded or blanked out of sheet stock. Thus the mold for a plastic

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object can be made without complicated lettering engraving, and the part produced from the mold can have applied to it many and varied markings, as orders require.

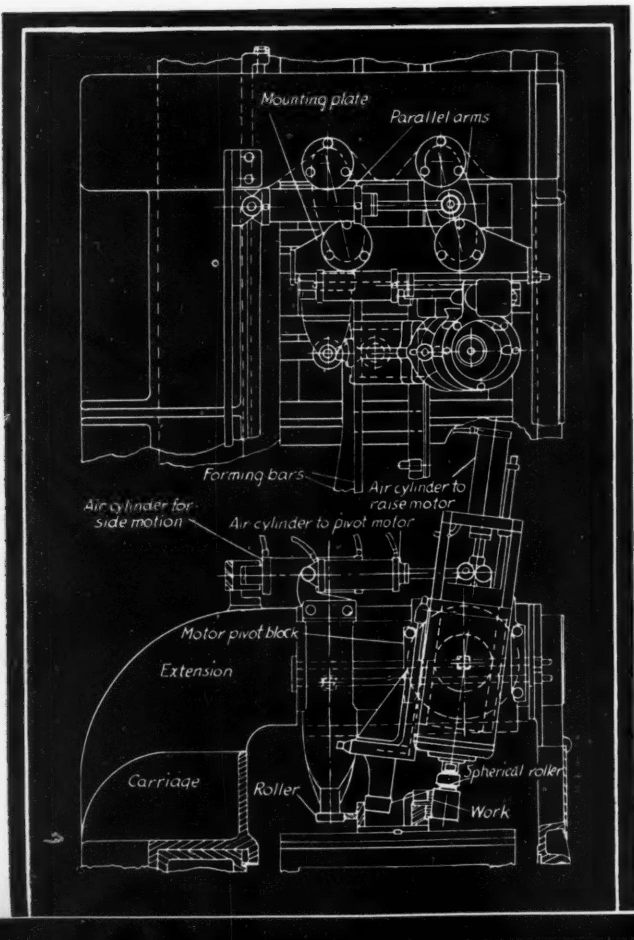
Control for Machining Variable Surfaces

By William Groen
Chief Engineer, Onsrud Machine Works, Inc.

TO MACHINE variable-angle surfaces on spar flanges for airplane wings involves accurate control of the cutter head motions. Illustrated in the drawing is one of the cutter motors for an automatic contour milling machine for this purpose. Variations in the surfaces being machined usually do not have a constant increase and, while the rate of change and the range of the variations are small, the limits of the angle and the flange thickness must be held within close tolerances.

Cutter motor is movable up and down in a slide by an air cylinder and can be adjusted for height. This slide turns on a pivot block and both are provided with suitable gibs to reduce lost motion to a minimum. The assembly is clamped on a vertical mounting plate on which a bracket carries a plain cylindrical roller. The mounting plate hinges with two parallel arms on an extension of the carriage, which is moved with variable speed on slides alongside the table.

Attached to the side of the cutter motor is an angle bracket which carries a spherical roller that can be moved up and down and sideways in relation to the cutter. Above the pivot block between the motor slide and a projection on the bracket for the plain roller, an air cylinder causes the motor to pivot. The plain roller and the spherical roller approach each other and come into contact with forming bars that are fastened on the table, parallel with the workholder, the whole adjusted so that the cutter enters the correct depth into the work.



Motor will not pivot if the two faces of the forming bars are parallel and a straight cut is made of any constant angle when the carriage is started. When both rollers move parallel laterally while cutting, a similar motion will be imparted to the cutter without change of angle. But when the plain roller only is moved sideways by the forming bar, then the cutter is forced to turn about a point in the center of an arc that describes the spherical roller; this point can lie on the cutting edge of the cutter. When both faces of the forming bars are not parallel with each other and with the carriage slide, the result will be a helical surface on the spar flange that can be made to answer any specifications such as offsets for skins or fastenings.

For profile milling with a constant angle, the motor is locked to a desired angle, using the air cylinder for side motion. The other cylinder and the spherical roller are then inactive. Either one or the other of the roller brackets may be utilized while air pressure holds the cutter to the work.

Test Unit Simulates Shock Loading

By C. O. Mitchell
Research Engineer, L. H. Gilmer Co.

HIGHLY accelerated belt testing machines too often are designed with insufficient consideration being given to the actual service the belt will receive. When this company decided therefore to build a test stand for purposes of developing a V-belt for use on the cylinder drive of various agricultural combines, this point was kept in mind.

From discussions with combine engineers and from experience, it was found that the average steady load on cylinder drive belts is approximately 5 horsepower, but due to variations in crop density, plus frequent heavy weed growth, the power demand goes up to 30 or 35 horsepower when the machine is moving through these areas in the field. So much material is fed into the machine that often the cylinder chokes up and eventually stalls. At this point the belt is forced to slip 100 per cent, creating a heat condition which burns the sidewalls of the belt. The frequency with which this occurs depends on a number of things, chief of which are: Belt tension, cylinder speed, horsepower of prime mover, condition of crop, and speed at which the combine moves through the field.

It was decided that the test stand should subject the belt to a steady load of 5 horsepower plus a shock load of around 40 horsepower, and this shock load should be applied more often than would occur in the field, say two times per minute.

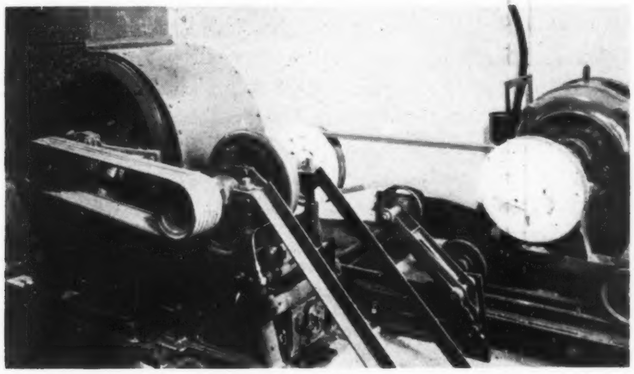
Time factor being important it would take too long to build a special motor under existing conditions. Therefore a 20 horsepower, 900 rpm 2-phase, 220/440-volt motor was applied. In order to absorb power a centrifugal fan of

sufficient capacity was utilized so that if necessary the steady load part of the test could be varied from a low of 5 horsepower to a maximum of 20.

On the driven shaft, intended to simulate the cylinder of the combine, a conventional hydraulic truck brake was installed, to be operated from a master cylinder actuated periodically by a cam. A ¼-horsepower, 1750 rpm motor operating through a small gear reducer gave a cam cycle every 25 seconds, which was satisfactory. The cam was designed to actuate the brake and release as quickly as possible.

After the test stand was completed it was necessary to have some means of measuring the shock load. Varying the amount of the shock load was easily accomplished by varying the belt tension through a spring-tensioned idler. Having on hand a clip-on ammeter of sufficient capacity, it was decided to calibrate the peak readings of the armature current caused by the stalling of the driven sheave. The time required for the brake to go on and off, and for the load to return to the steady value is 6¼ seconds, while the time the driven sheave is in a stalled condition was determined at 1¼ seconds. Maximum power transmitted to the belt by the deceleration of the motor armature was almost negligible, being less than one-half horsepower.

During these calibration tests it was necessary to add several braces to prevent the driven shaft, brake and



bearing assembly from being torn apart from the shock. Furthermore, all sheaves required a close fit and multiple set-screws to prevent their coming loose.

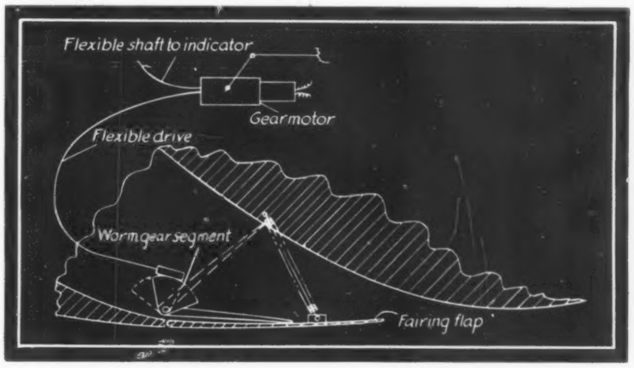
Test belt runs on two variable pitch sheaves and operation during the past year has been with the driven shaft set at 800 revolutions per minute, the fan set to absorb 5 horsepower, with the shock load peak set at 39 horsepower, running continuously twenty-four hours a day.

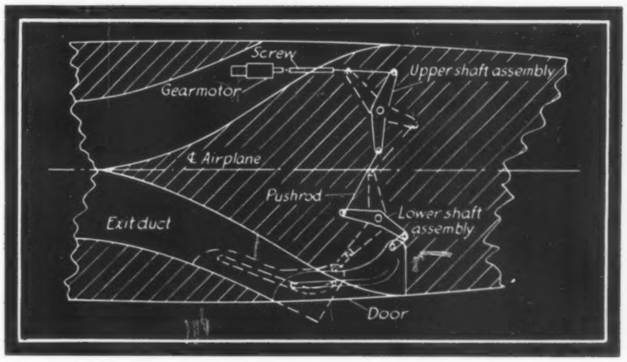
Thunderbolt Performance Increased by Cooler Doors

By Mark C. Benedict
Republic Aviation Corp.

ONE of the major problems on the Thunderbolt was to meet all the cooling requirements without jeopardizing its high aerodynamic efficiency. The present design is based upon maintaining tangential exit flow of all cooling air and, at the same time, keeping the smooth exterior lines of the airplane free from protruding doors or flaps as much as possible.

In the upper diagram is shown an oil cooler door arrangement. Integral with a fractional-horsepower direct-current motor with reduction gears is a screw and follower which contacts limit switches to stop the motor at the ends of the door travel. The follower also actuates an arm coupled to a door position indicator, which leads to the





cockpit. The flexible drive connects to a worm and spur gear segment which turn the shaft of the internal door. The normal operational range of the oil cooler doors is from closed to tangent with a fairing flap. This flap is held flush with the fuselage contour by a spring, providing a smooth exit for the cooling air. Under the most severe of cooling requirements, the inner door pushes the flap out into the slipstream and greatly increases the pressure drop through the cooling system.

A similar design, for an intercooler door mechanism, is illustrated in lower diagram. A fractional-horsepower direct-current motor and reduction gear drives a screw through a universal joint. Upper shaft assembly runs vertically and has three bellcranks mounted on it. The bottom one connects to the drive rod. The second one up has two arms, one of which is connected to the bottom of the right-hand door (not shown) and the other to a pushrod which interconnects across the ship with the vertical shaft assembly for the left-hand door. The top bellcrank connects with the top of the intercooler door. Lower shaft assembly on the left side has two bellcranks, the bottom one being connected to the pushrod and the bottom of the door, and the top one—through a pushrod—to the top of

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the door. This linkage actuates both doors simultaneously and identically. The door is a channel in section. The horizontal top and bottom legs are flat sheets with a cam slot in them as indicated. The vertical part is formed to the fuselage contour. This door is supported on four rollers, two of which are on the top and two on the bottom of the exit duct. The normal operational range of the door is from fully closed to a position straight forward so that only a gap appears in the fuselage side. This allows exit of the air with minimum turbulence. To meet severe cooling requirements, the door can open still further and at the same time turn (as shown in phantom) so as to produce both a smooth duct shape and large pressure drop through the intercooling system.

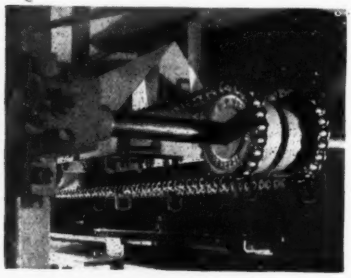
The effort extended in developing these auxiliary driving units to maintain smooth exit of all cooling air has been well paid by the increased performance which the Thunderbolt has shown.

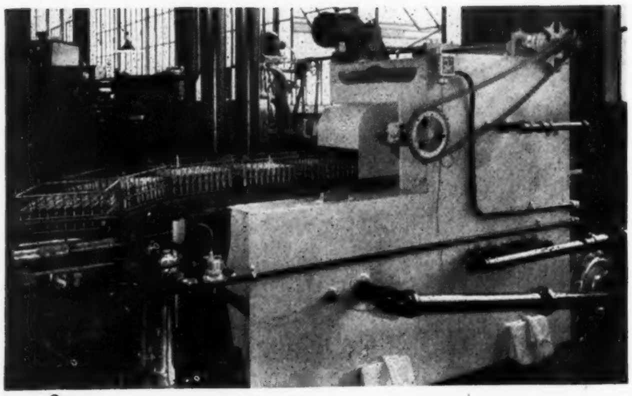
Designed for Varying Requirements

By William Nekola
Industrial Engineer, Barry-Wehmiller Machinery Co.

IN THE field of automatic handling equipment, frequently the test of a sound design is its adaptability to low-cost changes so that the same basic design can be used to handle a variety of products. Moreover, in the particular case under discussion it was desirable to build into the automatic metal-cleaning machine illustrated a considerable degree of accuracy in washing small parts having small cavities.

The problem was to build an automatic machine for removing various cutting oils or rust-preventive oils as well as metal ships from high-explosive shells. These shells, in sizes from 20 to 75 millimeters, lend themselves to many automatic processes during their manufacture and are consequently usually handled from station to station in wire baskets. The size of these baskets is generally limited by the fact that the total weight of the basket and product must not be excessive for easy lifting by operators. For various size shells, therefore, the dimensions of the baskets range from 12 by 18 inches to 10 by 10 inches with variations in height determined by the shell size.





To provide maximum cleaning action from the washing sprays it was decided to employ intermittent motion to drive the baskets through the machine. Since the service is relatively light, a six-sided geneva motion was chosen. This type of drive allows the projectile cavities to remain directly over the sprays for five-sixths of the total time allowed for washing.

This geneva motion is driven by a motor reducer to which it is connected by a roller chain drive. Through varying the sprockets on this drive, the necessary speed changes can be obtained. At this point in the drive, the entire mechanism is protected from over-load by a wood-block slip device.

From the geneva to the basket drive another roller chain drive is used. These sprocket ratios can also be changed to provide the proper amount of forward movement for each size of shell. The driven sprocket in this case has a slotted web through which it is bolted to the hub so the basket drive can be adjusted for correct register of the projectile cavities over the sprays.

Consisting of a double row of roller chains the basket drive is provided with special attachments which catch the upper rim of the basket as it is fed into the machine, as shown in the close-up view. The main framework of the machine is designed with sufficient clearance so that this drive may be placed higher or lower to accommodate the various heights of shell baskets. Operation of this drive is such that baskets can be fed to the machine by gravity conveyor at random. The chain attachments pull the baskets through the washing area and deposit them on another section of gravity conveyor at the discharge point of the metal cleaner.

In the metal-cleaning field, few machines are sold for exactly the same service. Hence, it was extremely desirable to avoid special engineering for each job by anticipating varying requirements within a reasonable range. In this way a uniform design was developed which could be offered to a wide field at a reasonable price.

Wet Driveshaft Doubles Service

By Robert B. Wallace
Project Engineer, Pump Engineering Service Corp.

DRIVESHAFTS for aircraft fuel pumps are, of course, governed primarily by standard machine design practice. There are, however, special conditions which must be satisfied, two of which are: Ability to run continuously with a possible maximum eccentricity of .006-inch, and minimum service life of 1200 hours with poor lubrication and no attention.

Essentially, there are two types of driveshafts, wet and

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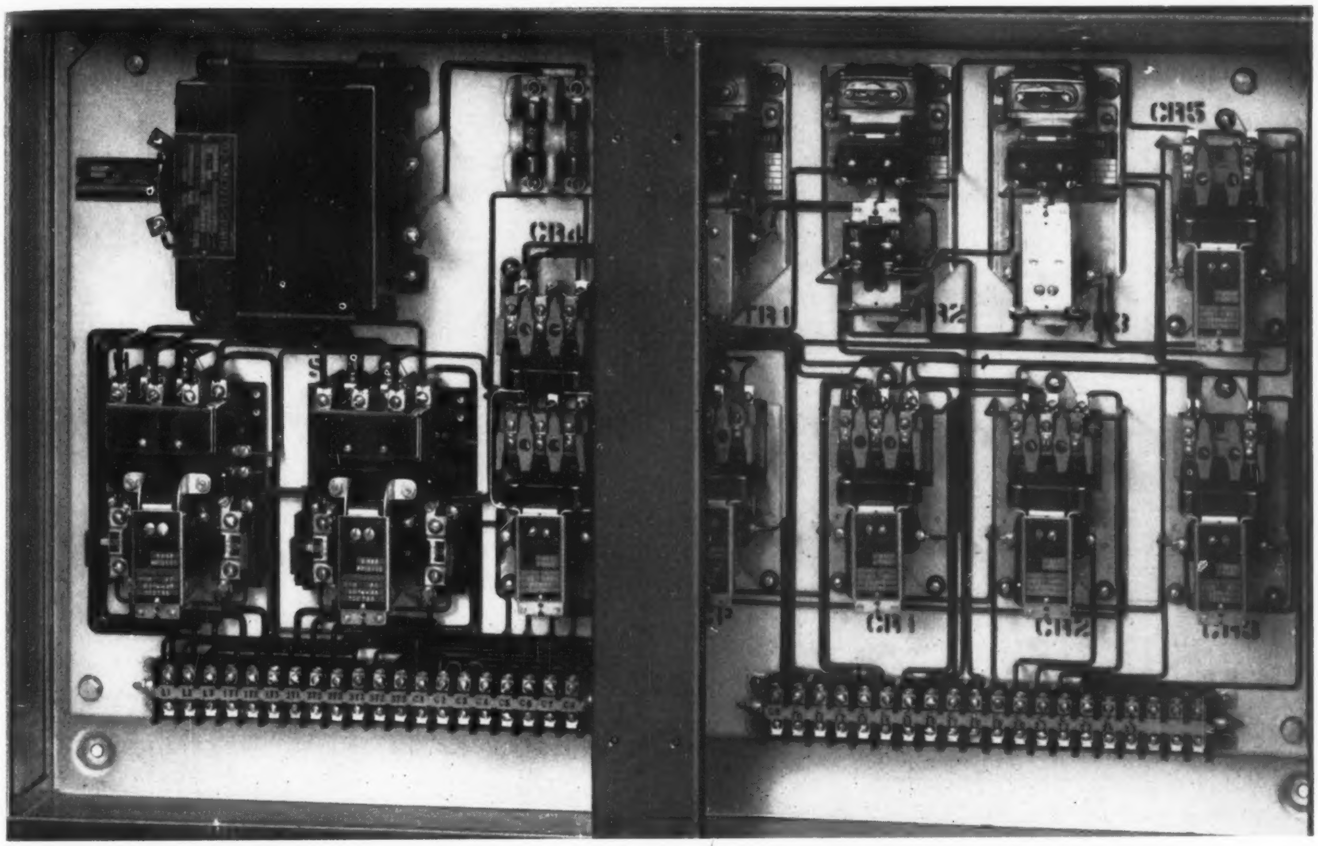


Fig. 1—Typical control panel with starters, timers, switching relays, fuses and control transformers

Selecting Components for Electrical Controls

By H. I. Stanback
Square D Co.

MACHINE design usually confronts the engineer with a dual problem in electrical control. He knows, to start with, what his machine must do and approximately what motions it goes through to do the job. He has probably also decided on the type of drive or motive power for each task.

Knowing his objectives, the dual problem is: Arriving at the electrical circuit and choosing the units which will be needed to put motors, solenoids, etc., through their paces. Primarily the electrical circuit determines what sort of units will be chosen, but often the circuit must also be designed with an eye to what can and what cannot be had in the way of control elements.

Without considering other aspects of circuit design, this article attempts to answer the question: "What control devices are available?" and to give brief, pertinent selection data for many of them. Most of these data have been included in TABLE I. Omitted from the table are lesser-used elements such as float switches, zero-speed and plugging switches. Electronic tubes also are not included.

This table is a "boiled-down" summary of types of units, their sizes and ratings, standard features, special modifications available, and points to consider when making a final selection or writing specifications†. It covers standard products of all manufacturers as completely as practicable, but naturally cannot, in every case, do justice to a particular manufacturer's complete line of equipment.

Discussion is limited, for the sake of brevity, to alternating-current control devices rated 600 volts or less at standard commercial frequencies of 25, 50 and 60 cycles. Higher voltage devices are seldom needed in machine circuits, and direct-current devices are so entirely different that it would not be practical to cover both. However, direct-current is becoming more frequently used in the manufacture of

†Analytical method for determining the minimum number of electrical elements to perform a given number of functions is discussed in a series of articles by R. S. Elberty—"Designing Control Circuits", MACHINE DESIGN, March, April and May, 1941.

TABLE I—Classification of Electrical Control Elements

Type of Equipment	Rating Classification	Rating Data	Number of Poles	Contact Arrangement	Standard or Special Features and Descriptive Data	Selection Considerations
Disconnect Switches	**Type A**—Heavy duty industrial. **Type C**—Standard duty industrial. **Type D**—Light duty or general use. **Double Throw**—Transfer switch for light duty.	30, 60, 100, 200, 400, 600 amperes and larger sizes. Mfgrs.' tables give h.p. ratings up to 50 for A and C.	2, 3 and 4 pole, fused and unfused.	Types A, C and D are single throw. Various other combinations of single and double throw switches are also available.	Built in two sizes for each current rating—one for 230 volts or less and the other for 575 volts or less. Types A ,C and D refer to enclosed switches but open-type switch mechanisms are often built into machines or control panels. (Manual motor starting switches with fuse clips or for use with time limit protective cut-outs are available in 30 and 60-ampere sizes.)	Type of service, voltage, number of poles, contact arrangement, current, fuse clip size for fusible switches, horsepower rating for motor circuit switch and type of enclosure. whether front or side operated.
Industrial Air Circuit Breakers	50. 100, 225 and 600 ampere frame sizes in standard or instantaneous trip constructions. Also classified by R.M.S. amperes capacity.	Available in a large number of trip current ratings. Consult mfgrs.' tables for data.	1, 2 or 3 poles in 50 ampere frame. 2 or 3 poles in larger frames.	Single throw, quick make and break. (600 volts or in 100 ampere and larger frames have thermal and magnetic trip.)	Built in two constructions for each rating—one for 250 volts or less and the other for 600 volts or less. Built in 50 and 100 ampere frame sizes with non-interchangeable trip units and in 100, 225 and 600 ampere frame sizes with interchangeable trip units. Shunt trip, undervoltage trip, auxiliary contacts and rear connecting studs are possible modifications	Whether standard time delay or instantaneous magnetic trip is desired, voltage, number of poles, frame size, trip current rating and interrupting capacity. Type of enclosure if any is required.
Manual Motor Starters	Rated by NEMA size number or h.p. Available as large as NEMA size 1 in non-reversing, reversing and two-speed types.	Sizes up to 1 h.p. not standardized. Table II gives sizes 0 and 1 ratings.	1 or 2 poles up to 1 h.p. 2, 3 and 4 poles for NEMA sizes 0 and 1.	Single throw quick make and break or slow make and quick break. (Some types also made in double throw.)	**Standard Features** Across-the-line starting, trip-free operation. Thermal overload protection with interchangeable heaters. External reset. (Some types have lockout on "Stop" button. None provide low-voltage protection or release.)	Size, number of poles, horsepower. Non-reversing, reversing, or two speed. Type of enclosure if any is required. Flush plates are available for built-in applications. Select heaters for motor full-load current.
Push Buttons	Rated as standard or heavy duty. **Note**—Standard duty stations are limited to use with size 4 or smaller contactors.	For control circuits only. Not h.p. rated.	Single or double pole.	Momentary contact or two units interlocked for maintained contact. Single circuit, double circuit, or three-point.	**Special Features** Palm-operated buttons Lockout latch—usually available only on bottom unit of p.b. station. Jogging latch. Cylinder lock buttons. Available in general purpose, surface or flush mounting enclosures with any combinations of p.b., sel. sw. and pilot lights up to 8 units. Flush plates are furnished for built-in installations.	Control stations selected by type of enclosure, flush plate or mounting desired, number, kind, and arrangement of p. b., sel. sw. and pilot lights and nameplate markings.
Selector Switches	The standard duty stations are not available in all the combinations or with all the features found in the heavy duty.	For control circuits only. Not h.p. rated.	Single or double pole.	Maintained contact, two and three position. S.P.D.T.. and D.P.S.T. (Also tandem units for D.P.D.T.)	Switches are available with arrows on handle arranged to permit side by side mounting as well as the standard vertical. Available in water and dust-tight, Class II, Group G or Class I, Group D enclosures with most necessary combinations up to 4 units. Available in standard duty pendant construction with p.b. only up to 10 units.	
Pilot Lights	(Time delay p.b. stations are available to provide low voltage release up to a maximum of 4 seconds and low voltage protection thereafter.)	Lamp voltage and watts or candlepower.		Note—Mfgrs. use transformers, resistors or capacitors for high circuit voltage.	Colors available—Red, green, blue, amber, white, frosted, or clear. Open type units furnished for box mounting or panel mounting, oil-proof and drip tight panel mounting units or complete stations up to 16 units in cast-iron enclosures are available.	Voltage, frequency and color of pilot lights. Contact arrangement or mfgrs'. symbol designation for p. b. and selector switch units.
Foot Switches	Ratings not standardized, although standard, heavy and mill duty are used as general descriptive terms.	For control circuits only. Not h.p. rated.	Single or double pole.	Single pole, single or double throw, or double pole single throw.	Built with general purpose, water and dust-tight, or Class II, Group G and Class I, Group D enclosures. Available with mechanical latch to hold foot lever depressed.	Number of poles and contact arrangement. Mechanical construction, shape and dimensions, and mounting provisions. Type of enclosure.
Master Switches		Varies according to application. See mfgrs.' data.	See mfgr's listings.	See mfgr's listings.	Includes drum switches, cam and rotating cam switches, pole changing switches, shipper rod control stations, etc. Reversing and nonreversing types for squirrel-cage and wound-rotor motors, single or multispeed. Some have special low-voltage protection.	Function of switch, contact arrangement. Mechanical construction, shape and dimensions and mounting provisions. Type of operating handle or mechanism.
Limit Switches		For control circuits. See mfgr's tables for ampere ratings.	Majority are single or double pole but specialized types may have as many as 13 poles.	Single or double throw. Some single pole switches have separate normally open and closed contacts.	**General Classes**—Maintained contact or spring return. Slow acting or snap action. **Descriptive Classifications**—General purpose, machine tool, precision, direct action, track type, hatchway, door, stroke limit, planer type, crane hoist, slack cable, gear type, travelling nut, cam or rotating cam. **Operating Members**—Roller on lever, rollers on forked lever, push rod, plunger, roller on push rod, levers, forked lever, cam, rotating shaft. Available in general purpose, weather-proof, water and dust-tight, or Class II, Group G, and Class I, Group D enclosures. Many small, open type units available for built-in applications.	Function, type of service, accuracy required, type of operating members or members, mfgr's. ratings, physical construction, shape, dimensions and mounting provisions. Type of enclosure.
Pressure and Vacuum Switches and Regulators	For motor circuit use or control circuit use.	Rated in h.p. and amperes. See mfgr's data.	1, 2 and 3 pole.	Usually single throw quick make and break. Some types available with single pole, double throw contacts.	**Basic Types**—Bellows, diaphragm, piston and Bourdon gage. **Standard Features**—Adjustments for pressure or vacuum setting and differential. General purpose, drip-proof, water and dust-tight, or Class II, Group G and Class I, Group D enclosures. **Additions and Modifications**—Overload protection, release valve, reverse action, manual disconnect lever, magnetic unloader, contact locking levers.	Type of service, fluid involved, range of pressure or vacuum settings, differential range, accuracy of control, number of poles, h.p. or current rating maximum surge pressure, and type of enclosure.
Temperature Switches and Regulators			Usually single pole.		**Standard Features**—Adjustable temperature setting and differential.	Type of service, range of temperature settings, differential range, accuracy of control, h.p. or current rating.

Temperature Switches and Regulators			Usually single pole.	with single pole, double throw contacts.	reverse action, manual disconnect lever, magnetic unloader, contac: locking levers. **Standard Features**—Adjustable temperature setting and differential.	h.p. or current rating maximum surge pressure, and type of enclosure. Type of service, range of temperature settings, differential range, accuracy of control, h.p. or current rating.
Magnetic Relays	Rated for control circuit use by definition although often used for light motor or solenoid loads. Sizes and ratings are not standardized.	Ordinarily rated in volts, cycles, and amperes. See mfgr's data for specific values. Some types also carry h.p. ratings.	Many common types are limited to 1, 2 or 3 poles. Multipole-switching relays are available up to 12 poles.	Single throw, normally open or closed, or double throw. Double throw contacts usually limited to 4 poles. Any combination of normally open and closed contacts up to 8 poles can be obtained.	Adjustable temperature setting and differential are standard. Voltage sensitive (series coil). Switching (usually shunt coil). Voltage sensitive (shunt coil). Current sensitive. Frequency sensitive (shunt coil). Open phase or reverse phase. Differential (Two or more windings). **Methods of Operation** Magnetically energized and held or mechanically held. **Additions and Modifications** Resistor in coil circuit for 3-wire thermostat overlapping contacts for circuit transfer (normally open contact closes before normally closed contact opens).	trol, voltage and current ratings. General classification or function, type of operation, number of poles, contact arrangement, voltage, frequency and current or h.p. rating. Pick-up, seal and drop-out characteristics and consistency of operation.
Magnetic Contactors	Classified by NEMA size number. See Table II. Note—Size numbers 1, 2, 3, 4, 5 and 6 apply only to magnetically held contactors. Mechanically held devices are available but the ratings are not standardized.	See Table II	2 to 8 poles for sizes 00 and 0.	Single throw, normally open or normally closed.	**Additions and Modifications** Overlapping contacts for circuit transfer. Mechanical interlock between two contactor units. (For reversing service.)	Size, number of poles, line and control voltages, cycles, method of operation. Number and kind of extra interlocks. Common or separate control. Number of normally open and closed poles for sizes 00 and 0. Type of enclosure if any is required.
			2, 3 or 4 poles for sizes 1, 2, 3, 4, 5 and 6 plus extra interlocks.	Single throw, normally open power contacts. Auxiliary contacts (electrical interlocks) may be either normally open or closed, or double circuit.	**Standard Features** Low voltage protection or release. Normally open interlock for 3-wire control holding circuit. **Additions or Modifications** Extra electrical interlocks. Consult mfgr's. data for number available. Some contractors may have as many as four extra single or double circuit interlocks. Dual voltage or frequency coils. Mechanical interlock between two contactor units. (For reversing service.)	
Magnetic Starters	Classified by NEMA size number or by h.p. rating in the case of reduced volgate or wound rotor starters. Across-the-line starters are available in sizes 0, 1, 2, 3, 4, 5, and 6.	See Table II	2 to 4 poles plus extra interlocks.	Single throw, normally open power contacts. Electrical interlocks may be either normally open or closed, or double circuit.	**Types Available** Nonreversing—contactor plus overload protection. Reversing—two mechanically interlocked contactors plus overload protection. Across-the-line—connects motor to full voltage lines. Reduced voltage—transformer, resistors or reactor used to reduce voltage to motor during starting period. Wound Rotor—resistors in series with rotor windings reduce starting current: some regulate motor speed. Combination—standard starter plus disconnect switch or circuit breaker in a single cabinet. Multispeed—contactors, overload protection for each speed. **Standard Features** Same as for contactors above. Single phase across-the-line starters may have reconnectable coil terminals for 110/220 volts. **Additions or Modifications** Same as for contactors above. Extra overload relays or various types of overload protection may be furnished. See overload relays in this table.	Type of starter, size, number of poles, line and control voltages, cycles and horsepower. Select overload relay heaters or coils according to motor full load current. Whether two or three-wire common or separate control is required. Starting duty for reduced voltage starters and complete secondary data for wound rotor motors. Motor connection diagrams, and full load currents for each speed. Number and kind of extra interlocks. Type of overload protection needed. Type of enclosure if any is required.
Overload Relays	Relays often given nominal size or ampere ratings to correspond with rating of contactor with which they can be used. Heaters or coils rated in amperes of motor full-load current. Contacts usually rated only for control circuit use. However, some types will break motor lines directly and are rated in horsepower up to 3 h.p.	See mfgr's data for current-time characteristics, voltage and current ratings and selection tables for heaters, thermal units or coils.	One pole for each heater or coil, or in some cases heaters or coils in two or three power lines will trip a single contact mechanism.	Usually normally-closed contacts trip open on overcurrent. Some types available with normally open or double circuit contacts.	**Thermal**—Melting alloy type or bimetallic type. Heat generated by resistance heaters or induction in a copper sleeve. **Magnetic**—Solenoid coil and plunger type with or without dashpot. Combination of magnetic and induction-thermal relay. **Types of Operation**—Inverse time delay relays trip quickly on heavy current, but not on momentary overload or normal starting. Instantaneous trip relays used to limit torque to a predetermined value. Must be short-circuited during motor starting period. Hand reset (can be used for either 2 or 3 wire control). Automatic reset (use with 3-wire control only). **Standard Features**—Interchangeable heaters, thermal units or coils. Some types have calibrated adjustments. **Modifications or Special Features** Special quick or slow trip thermal elements. Saturable core reactors or transformers for long acceleration. Electric resetting mechanisms for pushbutton operation.	Type of operation and type of relay. Full load current of motor and ambient temperature conditions. In most cases less expensive thermal relays provide sufficient protection. If relay tripping point must closely follow maximum safe heating curve of motor, or if special tripping characteristics are needed, consult mfgr's current-time curves for relays. These should be compared with load characteristics and motor heating curves. Consider voltage, frequency and ranges of trip settings and continuous currents when selecting coils. Specify hand or automatic reset. Select coils, heaters or thermal units from mfgr's. tables.
Timing Devices	Classified by type, timing range provided and accuracy. Contacts are usually rated in amperes but there is no standardization of sizes.	See mfgr's tables.	Usually single or double pole although standard multicircuit timers are available up to 6 poles.	Single throw, normally open or closed or double throw.	**General Types** Electric motor driven (synchronous or nonsynchronous). Pneumatic (transfer of air through restricted orifice). Dashpot (oil, air, mercury, etc.) Clockwork or escapement. Magnetic flux (d-c relay with rectifier). Thermal (heater and bimetal strip). Electron tube. **Function** Time delay after energization or de-energization. Some timers can be obtained as separate units for attachment to movable armature and contact assembly of magnetic contactor.	General type, function, timing range and accuracy required, contact rating, number of poles and contact arrangement, voltage and cycles. Sequence of operation for multicircuit timers.

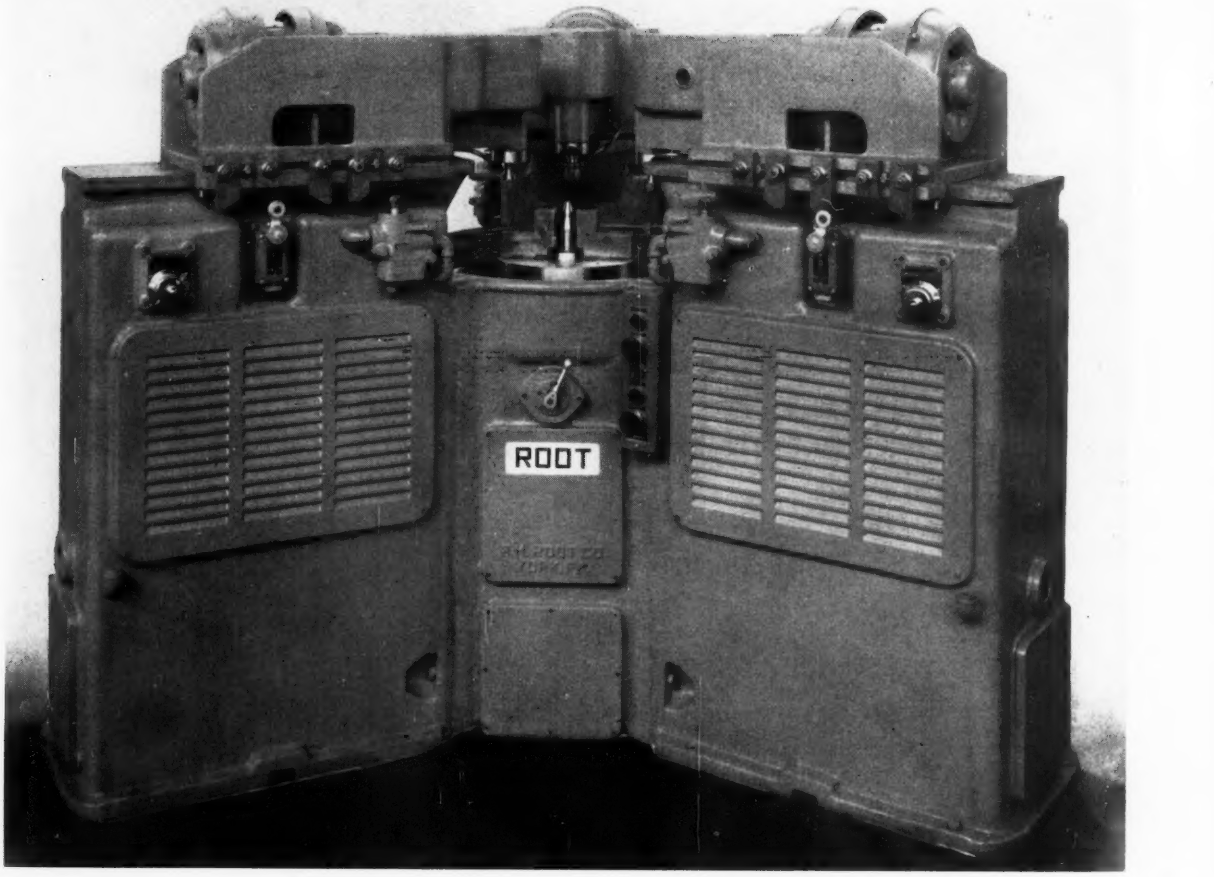


Fig. 2—Depressed mounting niche on hydraulic milling machine contains limit switches. Surface-mounted pushbutton station has two palm-operated buttons

machine tools and materials handling equipment, since many desirable characteristics of direct-current motors are not easily duplicated with alternating-current circuits—in particular, flexibility of speed control and dynamic braking. Complete lines of direct-current control apparatus are available which will duplicate most of the functions performed by the alternating-current devices discussed.

The elements listed govern electrical power or drive components such as motors, solenoids, brakes or solenoid valves. In addition the following types of devices which are neither control units nor drive components may be part of the machine electrical system:

1. Circuit elements
   a. Transformers
   b. Reactors
   c. Resistors
   d. Condensers
   e. Rectifiers, converters, inverters
   f. Fuses
2. Wiring devices
   a. Terminal blocks
   b. Plugs, sockets, jacks
   c. Connectors, lugs, hardware, etc.
3. Indicators
   a. Meters
   b. Temperature indicators
   c. Pressure and vacuum gages or indicators
   d. Liquid level indicators.

Disconnect switches or circuit breakers are necessary adjuncts to electrical systems, although they may or may not be furnished by the machine builder. Often they are included on the electrical control panel or built into the machine as a protective "shut-down" device.

Manual motor starters are mounted on, or built into, a great many machines where motors are small and remote control or sequence operation is not necessary. They are furnished with various styles of surface and flush-mounting enclosures, or are specified as open-type units.

Perhaps the classification "pilot devices" is of most importance to the designer, particularly if the electrical control panel is purchased complete from the control manufacturer. Such a panel is shown in *Fig.* 1, complete with starters, timers, switching relays, fuses and control transformers. Selection of control elements usually involves more than electrical characteristics and features. Physical dimensions, mounting provisions, mechanical sturdiness, ease of wiring and appearance are of prime importance.

Small and inexpensive standard-duty control stations are widely used for the simpler machine tasks, but they are only available in a limited number of combinations. Heavy-duty stations should be specified when more than three units are required or the application demands double circuit pushbuttons (pushbutton units having both normally open and normally closed stationary contacts for a single movable contact bar). The normally closed circuit on heavy-duty buttons is often used to advantage in electrical interlocking circuits such as may be found on multi-speed or reversing starters.

Palm-operated or "mushroom" buttons may be applied in "emergency stop" circuits or to facilitate operation of frequently used control units. They should not be used

where accidental operation might be harmful, since they are not protected by the guard rings or channels which prevent unwanted operation of standard buttons.

Sometimes addition of a "jogging latch" on a pushbutton station will allow inching the machine without the use of an auxiliary relay on the control panel. The normally closed contact of the double-circuit "jog" button is connected in series with the holding circuit of the motor starter. Closing of the normally closed contact is prevented until the jogging latch is manually released. Thus the starter will be energized as long as the jog button is depressed, but the holding circuit cannot be energized for continuous operation until the jogging latch is released.

Pushbutton, selector-switch and pilot-light stations assembled on steel plates can be flush mounted into a machine casting, while stations with sheet steel or various protective enclosures may be surface mounted at any convenient point.

Limit switch designs are not extensively standardized, which is probably an advantage. "Machine tool" type limit switches with flexible mounting facilities and varieties

however, are designed with separate double-circuit contacts and four terminals. This circuit separation may often be useful in keeping to a minimum the number of control relays necessary in a machine electrical circuit. Larger switches have two or more poles for the same purpose.

Various Reversing Methods Are Available

Zero speed and plugging switches, not included in TABLE I, may be used on alternating-current control applications where a motor must be brought to rest as soon as possible after the stop button is pressed. These special purpose devices have rotating shafts to be coupled to the motor shaft. Manufacturers have utilized various operating principles and achieve slightly varying results. In general, the control scheme requires a reversing starter which the zero speed or plugging switch automatically energizes to reverse the motor torque as soon as the stop button is pressed. This reverse torque quickly decelerates the motor, and the switch de-energizes the starter in time to prevent acceleration in the reverse direction. With some types,

TABLE II

Horsepower and Ampere Ratings of Starters and Contactors

Size Number	8-Hour Ampere Ratings		Maximum Single-Phase Horsepower			Maximum Polyphase Horsepower For Single-Speed or Constant and Variable-Torque Multispeed Motors			Maximum H. P. Polyphase For Constant H. P. Multispeed Motors		
	Open	Enclosed	110 V.	208-220 V.	440-450 V.	110 V.	208-220 V.	440-550 V.	110 V.	208-220 V.	440-550 V.
00	10	9	½	¾	—	¾	1	1	¾	¾	—
0	15	12.5	1	1½	1½	1½	2	2	1	1½	2
1	25	22.5	1½	3	5	3	5	7½	1½	3	5
2	50	45	3	7½	10	7½	15	25	5	10	20
3	100	90	7½	15	25	15	30	50	10	20	40
4	150	135	—	—	—	25	50	100	15	30	60
5	300	270	—	—	—	—	100	200	—	75	150
6	600	540	—	—	—	—	200	400	—	—	—

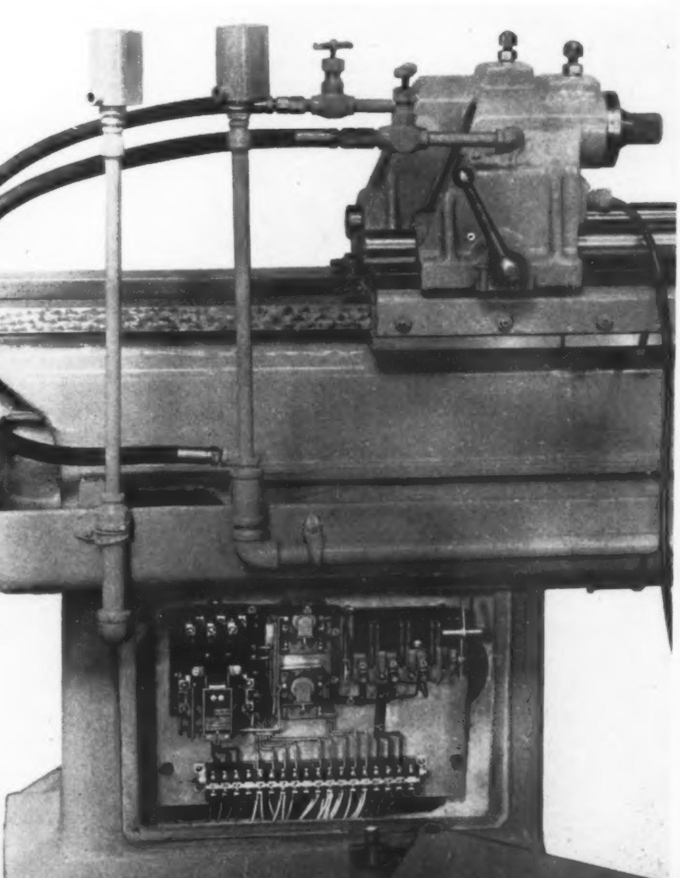
of operating members take care of a wide range of requirements. In *Fig.* 2 is shown a hydraulic milling machine with limit switches mounted in a depressed niche. Dimensions, shapes and operating arms or levels vary so widely that a designer can find almost any type of limit switch he wants as a standard item of electrical control. A number of specialized switches have been developed for certain types of applications which are common to various classes of machine tools.

An amazing variety of small limit switch mechanisms are available. These are provided with many different types of enclosures and operating members to satisfy a high percentage of machine requirements. They must be carefully applied, however, in order not to exceed their contact ratings.

Where solenoids or heavy control-circuit loads must be handled by the limit-switch contacts, there are precision type devices capable of the higher contact ratings required. Manufacturer's data and recommendations should be requested and carefully considered when there is any doubt concerning the loading of the limit-switch contacts. Continuous current-carrying capacities and inductive make-and-break ratings are both important factors for consideration.

Most of the smallest limit switches are single-pole, double-throw type with three contact terminals. Some,

Fig. 3—Starter, relays, disconnect switch and terminal block are mounted in cavity of lathe base casting



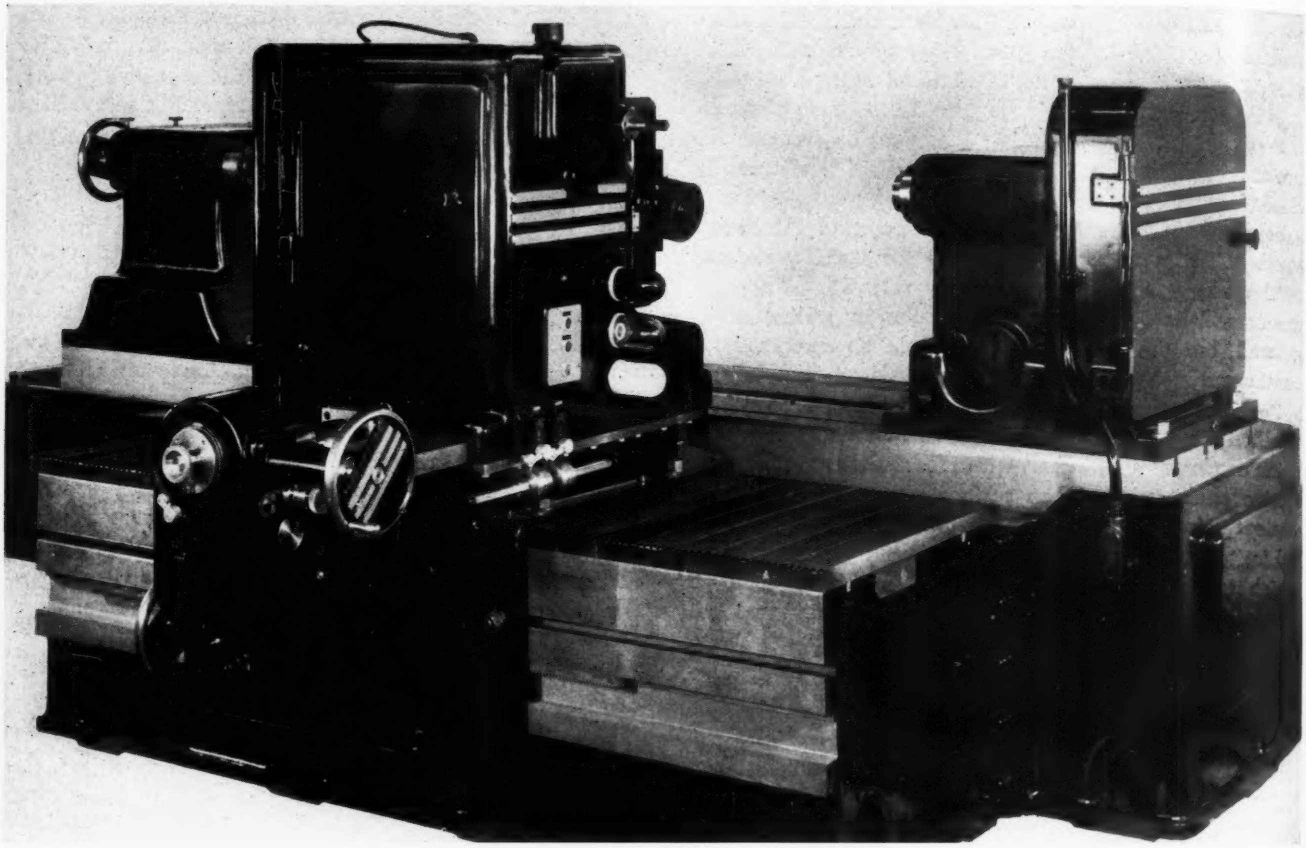


Fig. 4—Gear finishing machine has unusually large colored signal lights beside flush-mounted pushbuttons. Built-in limit switches, pushbuttons and lights obviate conduit and fittings. Control cycle is automatic, including full overload and undervoltage protection

the motor must actually begin to reverse before the starter is de-energized, while others operate as soon as the motor speed falls below a predetermined setting.

Magnetic relays, too, have lacked standardization in ratings or construction. Almost any size or contact arrangement can be obtained as a standard item. Switching, voltage-sensitive and current-sensitive relays are most often used and offer the widest selection. Pick-up, seal and drop-out characteristics are highly important when selecting voltage or current-sensitive devices, but less so when switching relays are being considered. Where a machinery builder wishes to stock switching relays there are types available on which poles may be easily changed from normally open to normally closed without extra parts.

Contact ratings should be considered as an important factor in relay selection, particularly if heavy inductive loads, such as solenoids or large size contactors, must be controlled. Since there are advantages from both the inventory and maintenance standpoints in using the same kind of device for a range of requirements, it is wise to consider the most severe service involved before choosing a particular line of relays.

Magnetic contactors and starters make and break the power circuits to motors, solenoids, etc. Close standardization has been achieved so that starters bought from any manufacturer will have identical current and horsepower ratings. NEMA size numbers have been assigned and ratings are in accordance with TABLE II. Contactors or starters will operate properly on voltages varying as much as 10 per cent above or 15 below their rated values.

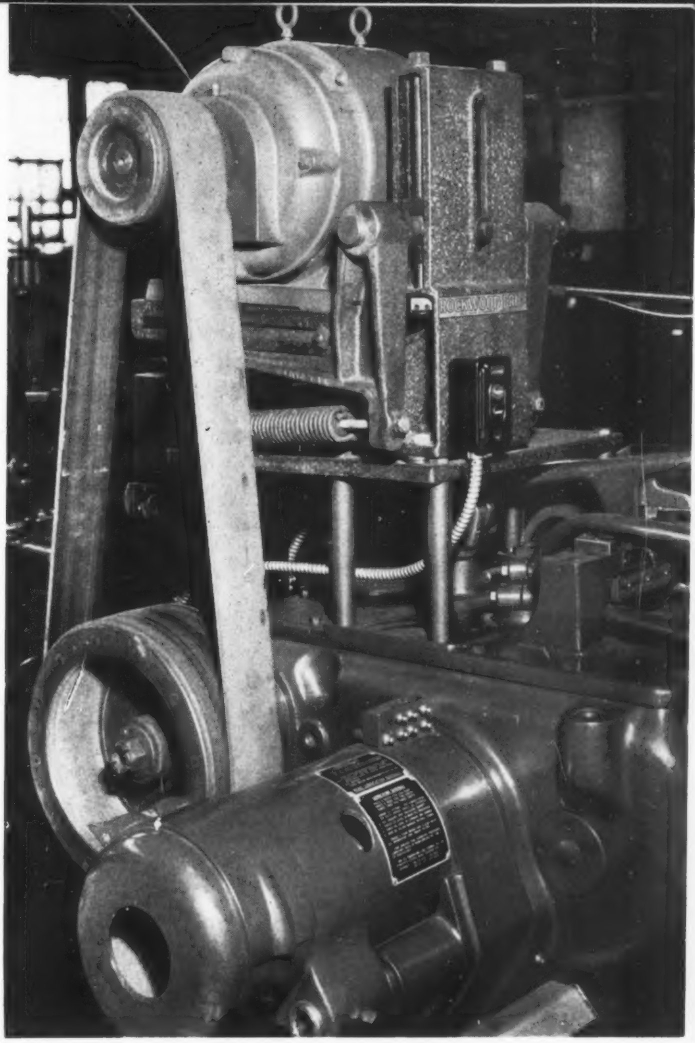
Overload relays may be furnished either as part of the standard equipment on a magnetic starter or as individual devices. For the majority of machine applications the smaller, less expensive thermal type relays provide sufficient protection.

In some cases a more specialized form of protection may be required. This might be accomplished with magnetic or induction relays, or with special forms of thermal relays. In these cases it is advisable to consult the relay manufacturer for recommendation if there is any doubt concerning the correct selection. *Fig.* 3 illustrates an application of starter, relays, disconnect switch and terminal block mounted in a cavity in a lathe base.

Time delay relays are commonly required in electrical circuits for acceleration, plugging, sequence timing, etc. A variety of types has been developed, each particularly adaptable to certain functions. In the gear finishing machine in *Fig.* 4, sequence timing for the working cycles employs pilot lights to indicate to the operator the conditions existing during the various cycles. The control system also includes full overload and under voltage protection by an interlock and thermal overload relays.

Most frequently used alternating-current timers are the motor-driven, pneumatic, dashpot and electron tube types. Motor-driven timers give high accuracy and can provide almost any necessary range of timing periods. Pneumatic and dashpot timers are less expensive and smaller but are less accurate and limited to timing periods of several minutes. Electron tube timers are extremely accurate but are limited to even shorter timing periods. Certain types of timers are available which can be attached to contactors on the control panel or operated by moving machine parts.

Fig. 1—Right—Vertical down drive for lathe uses pivoted motor base, belt tension being controlled by spring



Flat Belt Drives as Integral Parts

By Colin Carmichael

UNDER war conditions wise selection of machine drives is of paramount importance because of the twin requirements of maintaining peak production and conserving scarce materials. In reviewing the field of possible alternatives it is more than possible that the designer will find types of drives which, because of recent improvements in design and materials, can better fulfill requirements than other methods. In this class is the modern short-center flat-belt drive, which is widely used in machinery installations but which has so far enjoyed a rather limited application for drives forming part of a machine.

Short-center drives may be defined as those in which the center distance is not more than one or two times the diameter of the larger pulley. Because of their compactness they are particularly well suited to incorporation in machines as in *Fig.* 1, but care is necessary to insure that power is transmitted without either excessive slip or excessive belt tension.

Fig. 2—Steel springs beneath sliding plate of motor base maintain correct belt tension

Primary factors affecting performance are coefficient of friction between belt and pulley, belt speed, weight of belt, and elasticity of the belt.

For moderate belt speed drives, and the type of service commonly associated with them, a primary requirement of the belt is ability to yield momentarily under shock loads. Because this type of belt tends to change in length with varying loads and atmospheric conditions, such drives are usually designed with automatic tension control, thereby enabling full advantage of the shock-resistant belt to be realized. Formerly idler pulleys, which also increased the arc of contact on the smaller pulley, were extensively used but because of the reverse bending of the belt and the tendency to vibrate under pulsating loads this type of control has largely given place to simpler methods.

Modern tension control is accomplished by some form of automatic adjustment of center distance. Available for affecting this adjustment are:

1. Weight of the motor
2. Spring force
3. Torque reaction.

Use of spring force alone is illustrated in *Fig.* 2, which shows a compressor drive with the motor mounted on a slide held in position by an adjustable spring under the slide. Force exerted by the spring must equal the sum

of the horizontal components of the tight and slack belt tensions. Temporary changes in belt length do not appreciably change the tension. Permanent stretch is taken care of by adjusting the spring tension device.

In order to utilize motor weight and torque reaction in controlling belt tension the motor must be pivoted, as in *Fig.* 3. Relation between the forces acting is determined by taking moments of these forces about the pivot point. Thus for the particular arrangement shown in the center illustration of *Fig.* 3 the summation of moment is:

$$Wa - T_1 b - T_2 c = 0 \quad (1)$$

or

$$T_2 = Wa/c - T_1 b/c \quad (2)$$

where T_1 is the tension in the tight side of the belt, T_2 is the tension in the slack side and W is the weight of the motor. Since the power transmitted is proportional to $(T_1 - T_2)$, Equation 2 may be written

$$T_1 - T_2 = T_1(c + b)/c - Wa/c$$

or

$$T_1 = Wa/(c + b) + (T_1 - T_2)c/(c + b) \quad (3)$$

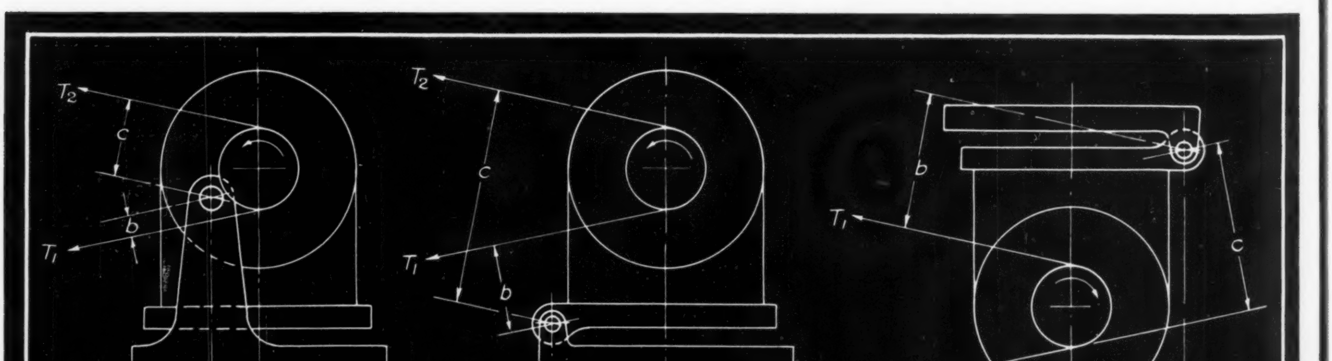
Also

$$T_2 = Wa/(c + b) - (T_1 - T_2)b/(c + b) \quad (4)$$

As indicated by Equations 3 and 4, both motor weight and torque reaction are controlling influences on belt tensions. By making a large in comparison with b and c the effect of motor weight becomes the more important factor. Equation 4 shows that slack tension diminishes as load increases, while the total tension $(T_1 + T_2)$ increases slightly provided the pivot point is nearer the tight side $(b < c)$ as in the center illustration of *Fig.* 3. In cases of "top-pull" (tight side on top) total tension would actually decrease with increasing load. To avoid this condition, which requires a larger overhang a, a better location of the pivot is as arranged in the ceiling drive shown in the right-hand view, *Fig.* 3.

When the pivot is located as in the left-hand illustration of *Fig.* 3

Fig. 3—Below—Location of pivot point for floating motor base determines relative effects of motor weight and torque reaction



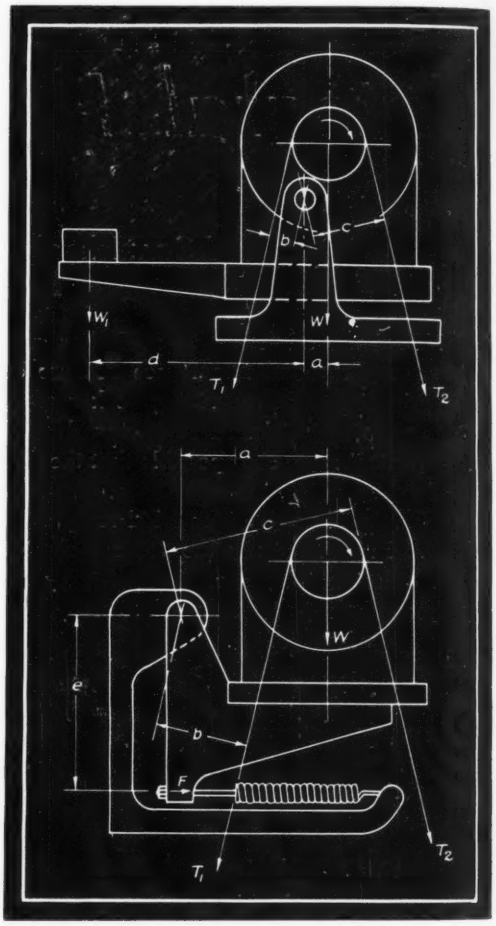
equations for belt tensions become:

$$T_1 = Wa/(c - b) + (T_1 - T_2)c/(c - b) \quad (5)$$

and

$$T_2 = Wa/(c - b) + (T_1 - T_2)b/(c - b) \quad (6)$$

Fig. 4—Below—Motor weight being unavailable for tension control in down drives a counterweight (upper) or spring (lower) must be used



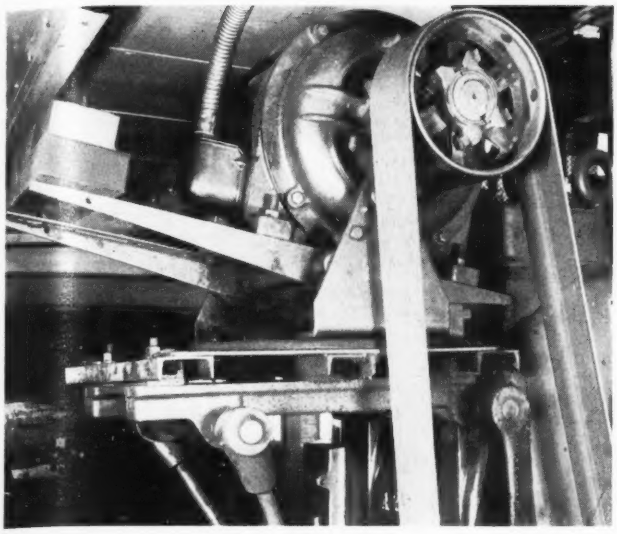


Fig. 5—Belt tension for down drive on vertical turret lathe is controlled by counterweight on floating motor base

It is evident that for this arrangement torque reaction can be made the governing factor and that for the drive to work, the tight side must be next to the pivot. An application of this drive to a vertical turret lathe is shown in *Fig. 5*.

Using a spring as shown in the lower illustration of *Fig. 4* the equations for belt tension become:

$$T_1 = (Fe - Wa)/(c + b) + (T_1 - T_2)c/(c + b) \quad (9)$$

and

$$T_2 = (Fe - Wa)/(c + b) - (T_1 - T_2)b/(c + b) \quad (10)$$

from which it is apparent that for total tension to increase with increasing load the tight side must be next the

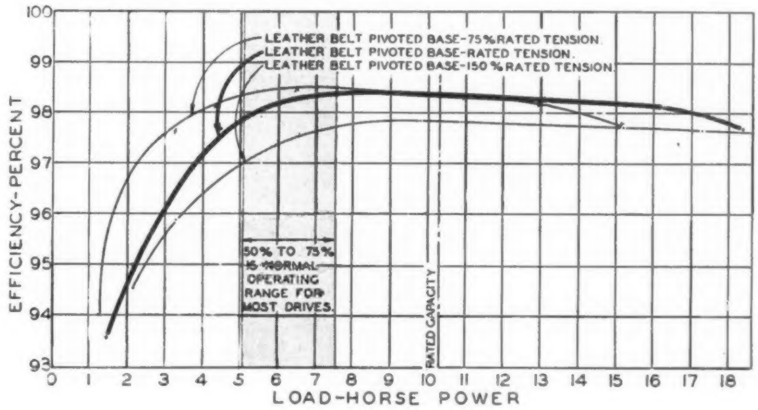


Fig. 6—Right—Shows detrimental effect of excessive belt tension on efficiency. Belt speed is 3161 feet per minute, motor pulley speed 1725 revolutions per minute, pulley ratio 2.16 to one

By making a small relative to b the effect of motor weight on belt tension becomes less important than torque reaction. Equations 5 and 6 also show that for the belt tension to be positive the pivot must be nearer the tight than the slack side ($b < c$). With this location both tight and slack side tensions increase with increasing load.

Exact location of the pivot for a particular drive is best determined from a graphical construction. Knowing the motor weight and the desired working belt tensions, also the line of action of these forces, the line of action of the resultant may be determined. Since commercial bases are provided with adjustable pivot supports the proper location is the intersection of the resultant force vector and the line along which the pivot may be adjusted.

Vertical down drives cannot utilize motor weight to control tension, hence an external force must be provided. Practical solutions include a counterweight or spring, *Fig. 4*. For the counterweight arrangement shown in the upper view force analysis shows that:

$$T_1 = (W_1d - Wa)/(c - b) + (T_1 - T_2)c/(c - b) \quad (7)$$

and

$$T_2 = (W_1d - Wa)/(c - b) + (T_1 - T_2)b/(c - b) \quad (8)$$

pivot. This form of drive, applied to a turret lathe, is shown in *Fig. 1*.

Effect on efficiency of varying the total tension above and below the correct value is illustrated in *Fig. 6*. In addition to lowering the efficiency excessive tension may cause bearing failure, and while it is often possible to overload belts considerably the limiting factor may be the capacity of the bearings rather than the belt.

Endless Belts Preferred

Belting materials include leather and woven belts, the latter either with or without rubber impregnation. Endless belts are preferred. In the case of leather such a belt is endless in the sense that the final splice is indistinguishable from the other cemented joints. Woven belts can be, and for high speeds must be, woven endless on special looms. For rubberized belts which are not woven endless, special methods of joining have been developed by which the ends of the plies are interlocked and vulcanized, the belt thickness and flexibility then being uniform throughout. Strength of such joints is usually 75 to 85 per cent of the strength of the belt.

In specifying leather belts the designer is faced with the choice of single-ply or multiple-ply belts. Because the multiple-ply belts cost more it is sometimes inferred that they are superior. Actually when the pulleys are small a

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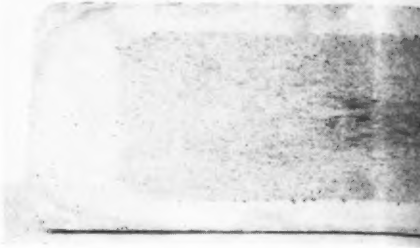


Wartime Metallurgy Conserves Strategic Materials

Part IX—Elements in Carbon Steels

By R. E. Orton and W. F. Carter
Acme Steel Co., Chicago

PHOSPHORUS: Phosphorus, present in steel as Fe_3P and fully miscible with iron in the proportions usually present, is held between .03 and .045 per cent in constructional steels, is between .09 and .13 per cent in low-carbon free-cutting steels, and runs up to .1 per cent in bessemer rail steel, sheet, strip and skelp. While generally conceded to be responsible for low impact strengths, Bullens (4)[*] reports that as long as the C plus P content does not exceed .3 per cent the room temperature impact is little affected. Increase beyond this will give a pronounced reduction, particularly at low temperatures.

Phosphorus has a disturbing tendency to segregate, diffusing slowly, with the result that it is not uncommon for areas to develop having two and even three times the phosphorus content of the average. Such segregation, when rolled out, may lead to "ferrite banding", *Fig.* 68. This region will show all the bad characteristics associated with a high phosphorus content. It should be noted that one part of phosphorus forms six parts by weight of Fe_3P, so that small quantities are effective.

[*]References in parentheses are listed at end of article.

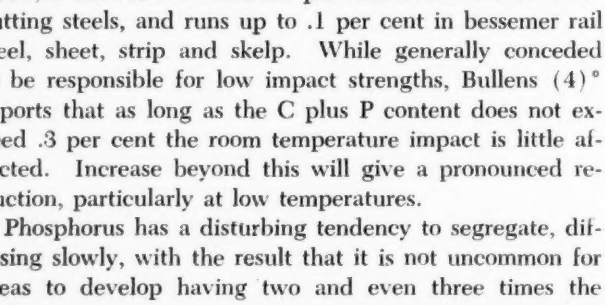


Fig. 68—Dendritic segregation of phosphorus causes migration of carbon to low-phosphorus region, resulting in higher pearlite content. Subsequent rolling produces banding. Magnification is 150 diameters

The element acts as a ferrite strengthener and increases the ultimate and yield strength of low-carbon steels markedly, more even than does carbon in the low carbon range. It also appreciably increases the upper critical temperature and exhibits good high temperature strength. For these last two reasons Bullens (4) considers it particularly valuable for vitreous enameling stock although current practice does not seem to recognize this. It is reputed also to give marked improvement in corrosion properties, particularly in conjunction with copper. In low-carbon steels it work hardens readily, becoming brittle and imparting thereby free-machining qualities.

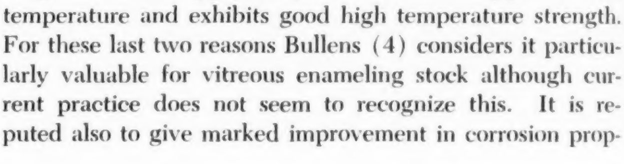


Fig. 69—Manganese sulphide inclusions act as chip breakers to contribute to free-machining qualities. Speed increases of 50 to 100 per cent are possible

SULPHUR: Sulphur in the absence of manganese will be present as FeS, having a solubility in iron at room temperature variously estimated at from zero to .02 per cent. In excess of this amount it forms thin membranes around the grains (5), producing a marked brittleness from content as low as .02 per cent. The melting point of FeS being in the neighborhood of 1800 degrees Fahr., it causes "red-shortness" with resultant cracking and even breaking in forging or rolling.

Fortunately, manganese has a strong affinity for sul-

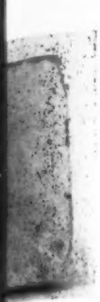
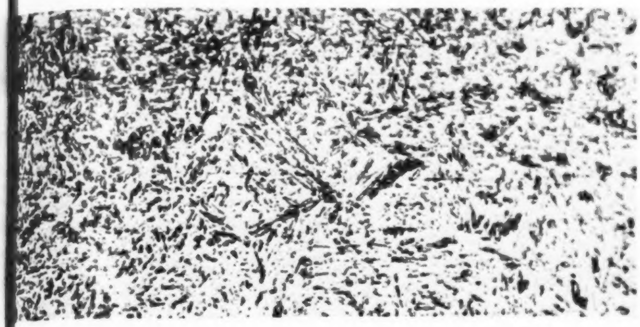


Fig. 70—Left—Segregation in rimmed steel slab. Analysis: .15 carbon, .042 sulphur. Analysis at center: .36 carbon, .1 sulphur

Fig. 71—Below—Excess nitrogen is present as nitride needles, contributing to hardness and brittleness. 500 diameters



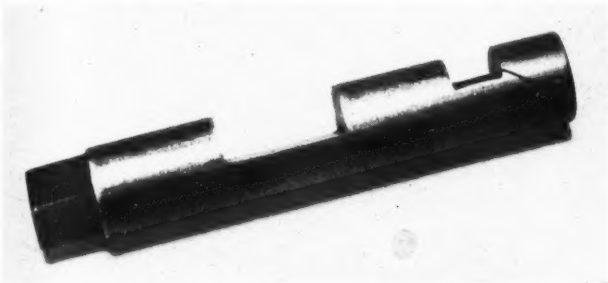


Fig. 72—Hydrogen embrittlement. This hardened part was pickled in hot acid to remove scale after heat treating. Nascent hydrogen, absorbed from acid, split piece

phur, and if present in sufficient quantity will reduce the FeS, forming instead MnS which will be present as small rounded globules having no more deleterious effect than any other nonmetallic inclusion. While less than two parts of manganese to one of sulphur are needed to form MnS, owing to the marked tendency of sulphur to segregate and to overcome the mass effect of the iron it is advisable to have from six to eight times the manganese. Even then the formation of over-rich sulphur areas, *Fig.* 70, in the high-sulphur steels particularly, is not unknown. The sulphur content of the constructional carbon and alloy steels is held under .05 per cent.

MnS acts as an excellent chip breaker and, in conjunction with Fe_3P in the low-carbon steels, contributes the free-machining qualities to "screw stock", *Fig.* 69. It may be present, in some cases, in as high an amount as .33 per cent (AISI grade 1113). In many high-sulphur steels the manganese is increased to offset the sulphur. Only these high-manganese grades should be used for heat-treated parts and even then only knowingly, fully cognizant of the danger to a highly stressed part of the presence of even a small quantity of FeS. This does not mean that there are not applications for heat-treated high-manganese, high-sulphur stocks. They should be applied, however, where failure would not have serious consequences or where the stress is low.

Inasmuch as neither sulphur nor phosphorus may be eliminated by the acid process, screw stock is commonly made in the bessemer converter. In fact, to such an extent is this true that bessemer stock has become (wrongly) practically synonymous with "screw stock".

Manganese: The prime function of manganese is as a reducer of FeO and FeS, and as such it promotes forgability and weldability as well as improving the surfaces of hot and cold-worked steel. It is present in considerable excess to insure a nearly complete reduction.

It will be present in nearly all carbon steels in amounts from a trace up to 1 per cent. An amount exceeding about 1½ per cent is treated as an alloy and as such will be discussed in a later article. It is only slightly soluble in the iron and that which is present beyond the MnS will be present as the carbide Mn_3C. In steels cooled to a

Fig. 73—Above—Longitudinal section of wrought iron showing slag inclusions. Magnification, 200 diameters

Fig. 74—Below—Fiber or grain flow of a radial aircraft engine crankshaft. Approximately three-eighth size.
—Courtesy Wyman-Gordon Co.

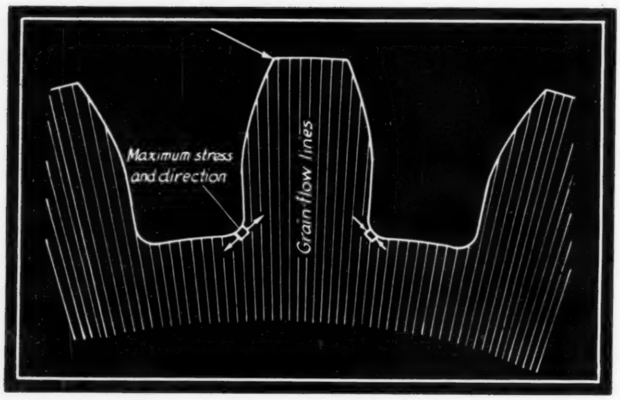


Fig. 75—Direction of maximum bending stress in gear tooth fillet is not parallel to grain flow obtained by conventional upset forging methods

pearlitic structure this compound will be associated with the Fe_3C carbide and will be metallographically indistinguishable from it. As a carbide former, amounts in excess of .3 per cent will increase the strength, wear qualities and response to heat treating.

SILICON: Silicon is a more effective deoxidizer than manganese. This better deoxidation means a lessened evolution of CO gas because of the elimination of the FeO for the FeO + C reaction. It is added to all killed and semikilled steels and is the principal deoxidizer used to control the rimming action in rimmed steels. It is also reported (1) as attacking, to some extent, the CO that is formed. It is further considered as effective in keeping nitrogen and hydrogen in solution (2), suppressing the formation of blowholes. Its action in this last respect is not too well understood. As usual, it is necessary to add more than that theoretically required because of the mass of iron to oppose the action.

Residual silicon in killed steels will run from .15 to .35 per cent. In the rimming steels it is lower, running from a trace to about .1 per cent. Appreciably more than this is treated as an olly. It is held to be present as FeSi soluble in these proportions in the iron and therefore not detectable metallographically, with a negligible effect on the properties. It does not contribute to the hot-rolling qualities, as does manganese. SiO_2 particles, distributed throughout the steel in submicroscopic size, are of value in promoting and maintaining a fine grain size.

ALUMINUM: Aluminum, the strongest deoxidizer commercially available, is added to all killed steels to finish them off and remove all but a trace of the FeO. Since only a small excess is required, a residual metallic content exceeding about .02 per cent must be treated as an alloying element. Some of the oxidized aluminum, Al_2O_3, will float out to join the slag, but the bulk of it will be entrapped in the solidifying metal. If the addition has been properly made it will be distributed in submicroscopic size, and as such affords an extremely effective grain size control (2), also discussed in Part VI*. This effect is better developed when used as a deoxidizer in conjunction with silicon.

OXYGEN: Oxygen will be present in steel in combination with the many elements that go to make up the nonmetallic inclusions. It will also be present as FeO in which form it is considered to be highly deleterious in amounts even as small as .005 per cent, causing brittleness and, in larger amounts, loss of ductility. It is also held responsible for "hot-shortness" in forging, rolling, etc., although some authorities maintain that sulphur must also be present (2). Its solubility is on the order of .005 per cent at room temperature, and amounts in excess of this contribute to strain and age hardening in low-carbon steels particularly. Its presence is not easily determined metallographically or analytically. Usual content in killed steels is under .005 per cent.

NITROGEN: Nitrogen is carried into the steel in large quantities by the blowing in the bessemer process, picked up from the atmosphere brought in for the combustion of the fuel in the open hearth, and carried in by the action of the arc in the electric furnace. Commercial steels contain from a trace to .03 per cent—part as dissolved nitrogen and the excess as Fe_4N which may at times show up as nitride needles, *Fig.* 71. Deoxidizing elements tend to suppress the formation of Fe_4N and their absence in rimmed steels may lead to higher contents of the compound. The Fe_4N is generally considered to contribute an embrittling effect. It is particularly harmful in low-carbon, rimmed steels intended for deep drawing and severe forming, being held primarily responsible for "age-hardening", "strain-aging" and "blue-brittleness" (6). The determination of the small quantities present is difficult and for this reason a great deal remains unknown about its effect.

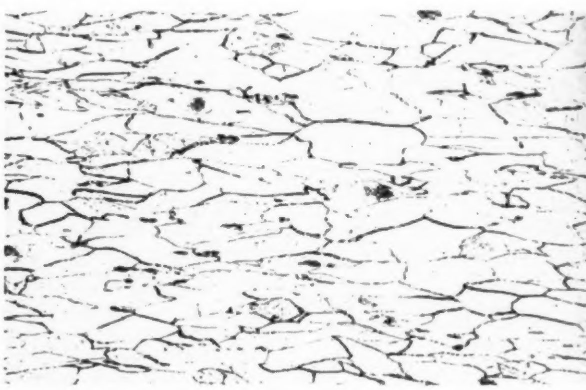
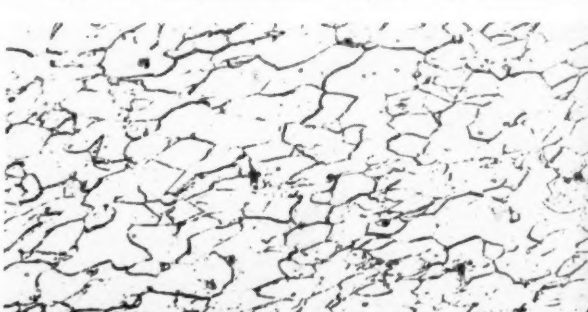


Fig. 76—Above—Longitudinal view of cold-rolled steel showing the directional effects imparted to the grain structure by even a moderate cold rolling. 250 diameters

Fig. 77—Below—Transverse section of cold-rolled steel of Fig. 76. Magnification is again 250 diameters



*MACHINE DESIGN, Jan., 1943, Pages 58 to 62.

HYDROGEN: Hydrogen will generally be dissolved in liquid steel in small amounts, probably picked up from dissociated water vapor or from the fuels used in the open-hearth process. The solubility drops with solidification and cooling of the steel as does also the ease of diffusion; so, in sections of any size, it may be entrapped within the metal structure. It will then diffuse slowly to the surface or to the nearest blowhole, inclusion or other discontinuity. Zapffe (7) has demonstrated that pressures sufficient to rupture the metal are not impossible. The extreme pressure is believed to force the hydrogen into slip or cleavage planes or into other metallographical discontinuities, literally wedging the metal apart. While the hydrogen will diffuse to the surface in time, it leaves the metal in somewhat the same condition as over-cold-worked material, making it subject to brittleness and fatigue

Fip. 78—Left—Pipe in steel ingot was not welded shut in the hot rolling, resulting in failure in drawing operation. Blank for pipe flange. Approximately one-half size

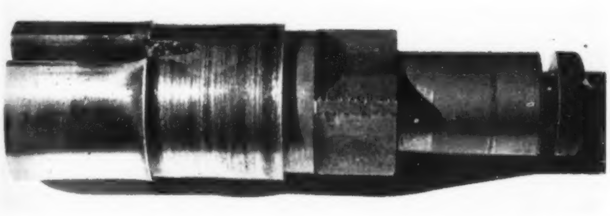


Fig. 79—Failure of bearing surface of SAE 4140 cold-drawn steel stretcher drum is due to decarburization

cracks. This condition may be eliminated by annealing unless it has proceeded to the point where an actual incipient failure has occured. Hydrogen from steel has also been considered responsible for blistering of paint and vitreous enamel (7) and for checks, tears, flakes, etc., in castings and forgings (8).

Hydrogen in the atomic state will diffuse fairly easily through steel, even at room temperature. Liberation of nascent hydrogen by electroplating, pickling, *Fig.* 72, and welding operations is a potential source of embrittlement. The danger of damage from precipitated hydrogen may be eliminated by holding at an elevated temperature for a sufficient time to permit the hydrogen to diffuse to the surface. This procedure has cured the troubles with flakes and shatter cracks in steel rails (9, 10 and 11).

NONMETALLIC INCLUSIONS: All steels contain a certain amount of entrapped oxide particles, MnO, SiO_2, Al_2O_3, and their slags, together with dissolved FeS, MnS and other materials. Those developed in the final deoxidizing operation will generally be small and fairly uniformly distributed except that the metal which freezes first will have a larger amount than that freezing last where there has been more time for it to float to the top of the ingot.

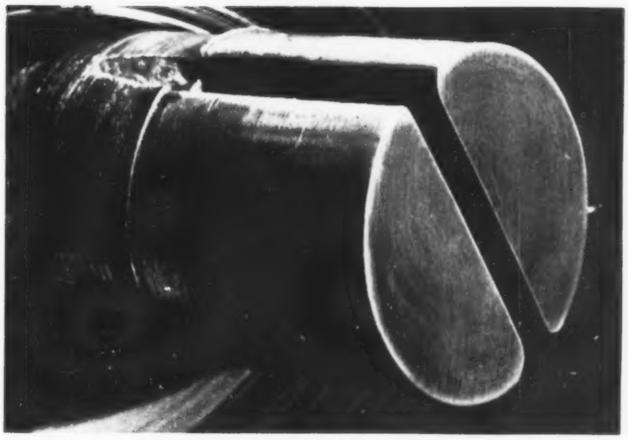


Fig. 80—End view of drum of Fig. 79 etched to show de-decarburized surface of the cold-drawn stock

There may also be larger bodies due to slag entangled in pouring, pieces of refractory, etc. The slag particles will be rolled or forged out in the hot working, contributing to the directional properties. In the case of wrought iron made by the old puddling process this slag may be large and occupy an appreciable portion of the metal bulk, *Fig.* 73.

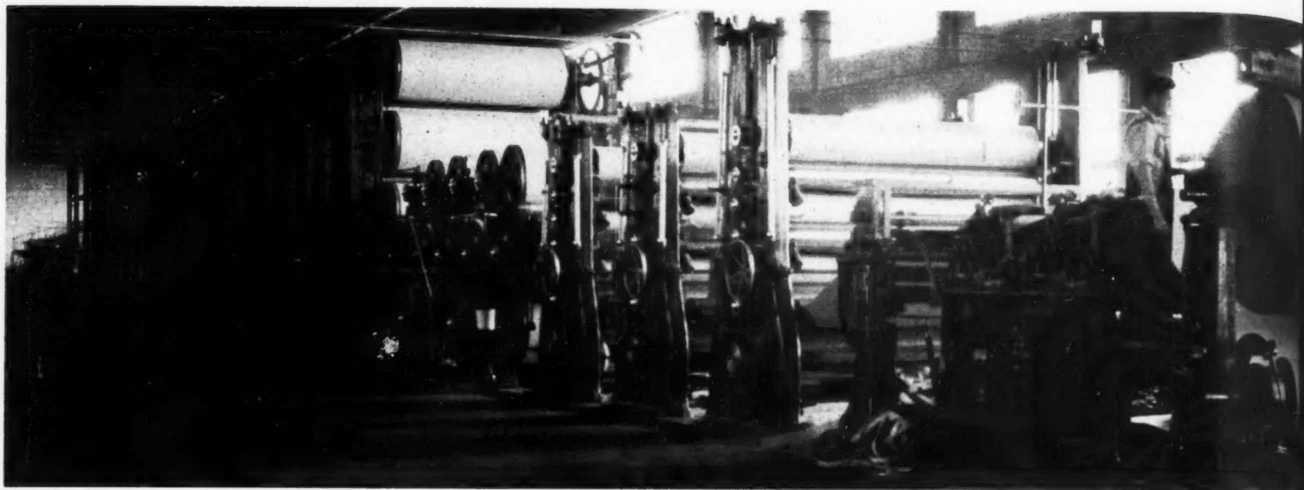
Al_2O_3 will contribute to cutting tool wear, but the other inclusions, such as sulphur and phosphorus afford some free-machining qualities. There is little question, however, that this "dirt" is harmful to parts subject to repeated loading, reducing the endurance limit. The effect will be much more severe in heat-treated steels, particularly those of high hardness, due to greater notch sensitivity. In actual application the effect will depend upon the location and orientation in the high-stress region, so that some parts may stand up where others made from the same steel might fail.

Since it is difficult to obtain representative samples, rating charts for inclusions have never proved too satisfactory.

SEGREGATION: The foregoing discussion has assumed that all materials were well and uniformly distributed. In solidifying, however, two important types of segregation occur. Owing to the fact that impurities lower the freezing point, the metal freezing first is always the purest. Since the freezing will be from the mold wall inward, a progressively higher content of manganese, sulphur, phosphorus, silicon and carbon will occur as it proceeds to the center of the ingot, *Fig.* 70. Also, in solidifying the metal forms large, tree-like crystals or "dendrites" the axes of which freeze first, so that they will be purer, whereas the interspaces will be much richer in the impurities. This dendritic crystal form disintegrates on further cooling and the carbon will, in general, diffuse to a uniform distribution; but a certain amount of the segregation of the other elements will usually persist, even after considerable hot working. If this is not too great it may be accepted as the expected constitutional defect of steel, but if too pronounced it may be responsible for considerable trouble.

Segregations will be rolled out and elongated and, together with the elongated slag inclusions, are responsible for the so-called "grain flow" or "fiber" of hot-worked steels. A great deal of stress has been laid on the impor-

(*Continued on Page* 194)



Precise Control Enhances Machine Performance

By Fremont Felix
General Electric Co.

MODERN trends in machine and drive developments toward faster speeds, more production, greater use of automatic features, improved quality and more accuracy have become even more pronounced by the pressing needs of war production.

Greater flexibility is demanded from electric drives which are being called upon to perform an increasing number of functions to meet widely varying operating requirements of machines. A few examples of these functions are:

1. Controlling the current of a reel motor to maintain any desired tension in a strip of steel being coiled on a core as the diameter builds up
2. Holding accurately the speed of a paper-making machine, *Fig.* 1, at any desired value over a wide range to permit the production of more varieties and grades of paper from a single machine
3. Positioning accurately the electrodes of an arc furnace to maintain the desired power in the arc throughout the melting and refining process
4. Delivering smoothly the maximum acceleration and deceleration of which a reversing machine, such as a planer or shovel, is capable without running or braking
5. Matching accurately the speeds of two or more stands of the same mill to maintain product uniformity at the maximum speeds permitted by the equipment

A new electrical unit, the amplidyne, has been designed to meet these requirements. Outwardly similar to a conventional motor and generator, its ingenious and unique use of a short circuit and compensating winding creates such precise electrical balance that an electrical signal as small as half a watt will release kilowatts of power capable of controlling the most powerful electrical machine.

Shown schematically in *Fig. 2a* is a conventional two-pole 10-kilowatt direct-current generator driven at constant speed. For the sake of simplicity, the armature is shown serving also as commutator and a single exciting field coil is shown on the north pole. The small circles with dots show conductors where the current is directed toward the reader and the small circles with arrow tails show conductors where the current is directed away from the reader.

Creates Stationary Armature Flux

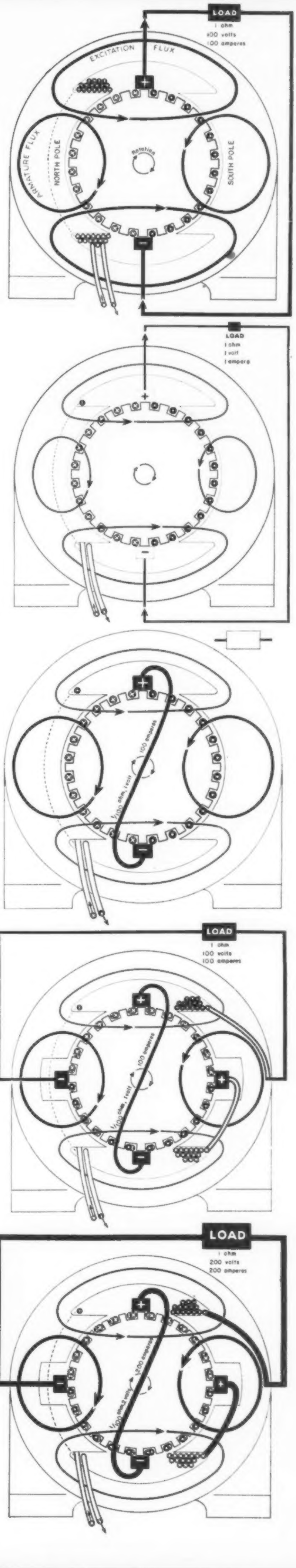
About 100 watts of excitation power supplied to the field coil creates the excitation flux. This flux produces a full-load voltage of 100 volts, which circulates 100 amperes full-load current through the load, taken as a resistance of one ohm.

In flowing through the rotating armature conductors, the load current creates a stationary armature flux because the armature conductors on the left of the brush axis always carry current in the same direction and the armature conductors on the right of the brush axis always carry current in the opposite direction. The combined effect is the same as that of a stationary solenoid directed along the brush axis, producing flux as shown in the left and right flux loops. This armature flux is of about the same magnitude as the excitation flux but does no useful work.

With a smaller field coil, and with excitation power reduced from 100 watts to one watt, the same conventional

Fig. 1—Left—Paper-making machine extends range of products, increases production and reduces spoilage with amplidyne control

Fig. 2—Right—Schematic diagrams illustrating the principle of the amplidyne unit



a

b

c

d

e

generator appears in *Fig. 2b*. The new reduced excitation power creates only one per cent of the original excitation flux. Voltage at the brushes is reduced from 100 volts to one volt, and the load current, also reduced from 100 amperes to one ampere, produces only one per cent of the former armature flux.

A short circuit across the brushes, as in *Fig. 2c*, restores the armature current and consequently the armature flux to their full original values. This is because the internal resistance of the armature winding is assumed to be 1/100 of the load-circuit resistance. The load has been disconnected. Excitation power and flux continue to be extremely small, but they now control the full-sized armature flux.

To put the short circuit to work two new brushes are added, as in *Fig. 2d*, one in the center of each armature flux loop, just as the conventional brushes are located in the center of the excitation flux. Assuming that these new brushes are not connected to any load and only the voltage between them is being measured, the armature flux produces full voltage, 100 volts, between the new brushes. Connecting these new brushes to the same load—one brush directly, the other through a compensating field shown on the south pole—then 100 amperes, full current, circulates through the load. In the same armature conductors, the new load current adds to and subtracts from the short-circuit current. This is shown by the four different combinations of "dots" and "tails" seen on the armature conductors.

Flux Is Neutralized

However, the new load current in the armature conductors cannot set up its own armature flux which would be directed from right to left because any tendency in this direction is neutralized by a compensating field of equal and, as shown by the dots and tails, of opposite strength. The output of 10,000 watts is released by an excitation power of one watt. This is an amplidyne.

Assuming that the excitation current is suddenly doubled (an increase from one watt to 4), *Fig. 2e*, instantly the short-circuit current doubles, producing double output voltage (200 volts) and forcing double current (200 amperes) through the load. Thus, by merely raising the control input by three watts, output is raised from 10 to 40 kilowatts. To obtain comparable changes in output in response to *minute changes* of excitation with conventional gen-

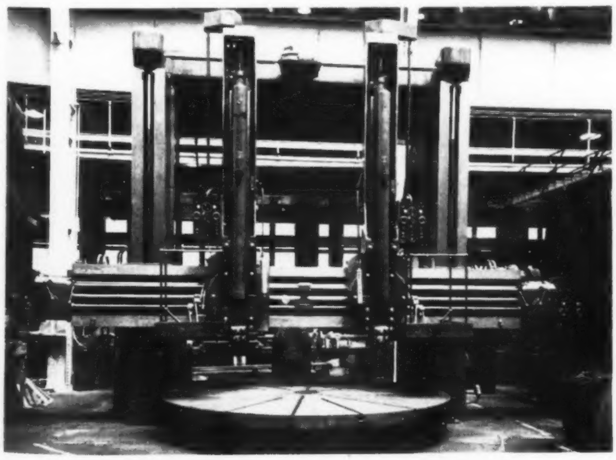


Fig. 3 — Boring mill is provided with automatic and precision preset positioning

erators would require two generators—a small control signal would excite the first one; the output of the first would excite the second. The output of this second generator would considerably amplify the small control signal to the first one but with a cumulated delay in response.

In the amplidyne, the equivalent of a full-size exciter, utilizing the same armature structure and conductors, is available to excite the output generator for fastest response.* The speed of response is further accelerated because the output flux is produced by the armature conductors from within the armature structure so that even the flux which leaks through the air produces useful voltage. An entirely new combination of amplification and speed is provided—two stages of amplification faster than any single stage could be, delivering 10,000 to 1 amplification and reaching full output in 1/10-second.

Four Fields Control Response

Because so little power and space are required for the control field, four are utilized instead of just one field. One provides a definite standard of reference, the others "tell" the amplidyne how different objectives are being met. The unit will respond to the resultant action of all the fields and amplify it in the same manner as for a single field.

Each of these fields is easily adjusted by a small resistor or other means, and since the current requirements of these fields are small their action may be blocked automatically by small rectifiers as long as a certain operating condition or limit is not reached. This use of multiple fields greatly reduces the number and size of control devices required to obtain a certain performance. Also, considerable flexibility can be built into the equipment, permitting operating limits to be easily changed if conditions require it.

Better Operation Realized

Because the small fields invite the use of greater number of controls, automatic operation can be realized to a greater extent. Also, because of the forcing action of the amplidyne, together with its practically instantaneous response, machines excited in this way deliver maximum performance under fast-changing conditions.

If, because of a sudden change in operating conditions, the generator voltage, current or speed becomes too high, the current in the corresponding amplidyne field is increased and the net excitation of the amplidyne decreases or is even reversed, which acts as a powerful corrective to restore the desired operating conditions.

An example of positioning to rest in combination with wide-range speed control is an application to a multiple-head boring mill, *Fig.* 3, where an amplidyne permits setting of the tool within .002-inch in any desired position within ten-foot travel. The two motions on each head of the mill are controlled by suitable motor-operated leadscrews. For each head the control motor is arranged with a double-throw mechanical-clutch mechanism so that it may operate either leadscrew.

The operator may preset the next cut to be made by means of dials registering feet, inches, and thousandths of inches. When one cut is finished it is only necessary to clutch in the motor to the proper motion, press a button, and the equipment will automatically move the cutting tool to the exact position for the next cut.

This positioning control is obtained by a series of limit switches and accurate mechanical means of operating these from the motion of the heads. Each direct-current control motor is separately excited and receives its armature power from an amplidyne, the field excitation of which is applied through circuits controlled by the precision limit switches. Low control-power requirements permit these switches to be small in size and hence accurate in performance.

Speed of the control motor is definitely held at any set value as shown in *Fig.* 4. Excitation is supplied from a

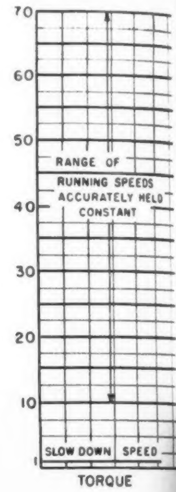
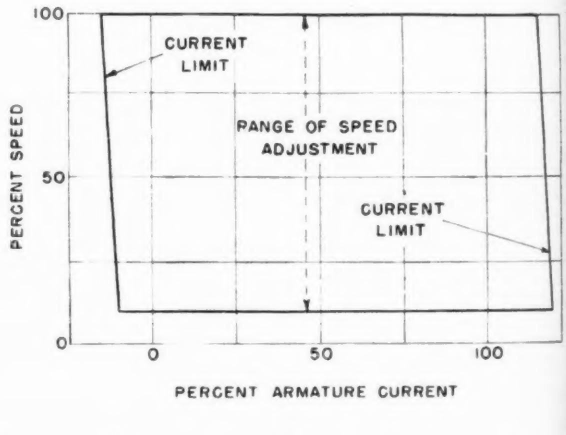


Fig. 4 — Right — Chart showing speed range and accuracy obtained on boring mill

Fig. 5—Below—Speed-adjustment and current-limit diagram for paper machine drive



voltage-matching circuit. This consists of a pilot generator, driven from the control motor, and a potentiometer circuit across the excitation source. When the slow-down limit switch is reached the motor is slowed to one-fiftieth rated speed by a change in potentiometer connection. This low speed is held accurately regardless of the friction conditions which are encountered, thus permitting accurate positioning by the final limit switch.

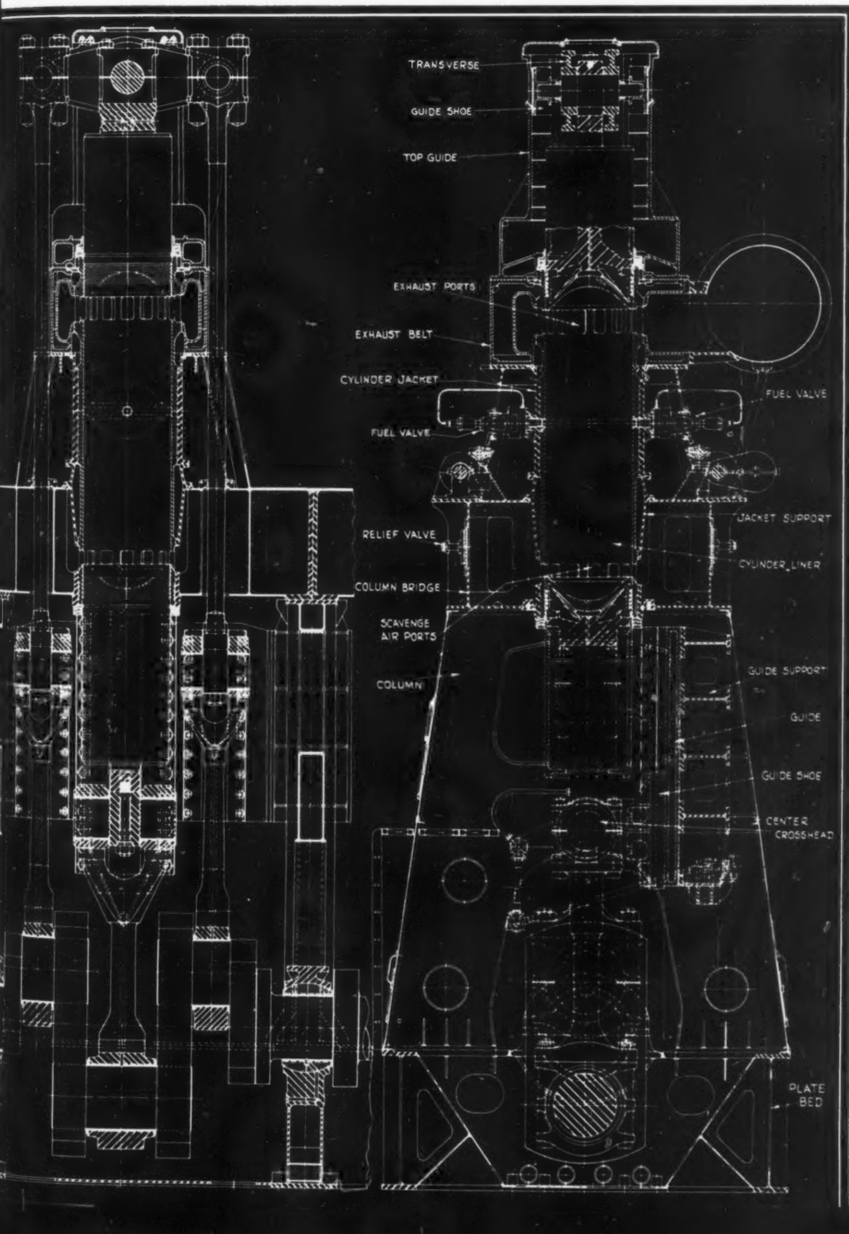
An example of wide-range speed control in combination with current limit is the accurate control of the speed of a paper-making machine such as shown in *Fig.* 1 where it is highly desirable to assure a uniform product with minimum waste. A wide range of operating speeds is also desirable so that both light and heavy-grade paper may be made on the same machine. Here, the main drive motor is supplied by adjustable generator voltage

(*Continued on Page* 202)

Solving the Diesel Drive Problem

TRANSMISSION of power from large marine diesel engines has been accomplished in an interesting variety of ways in the notable ships recently designed for the United States Maritime Commission. These developments were discussed at a symposium held under the joint sponsorship of the Society of Naval Architects and Marine Engineers and the American Society of Mechanical Engineers at the recent annual meeting of the A.S.M.E., an abstract of which is here presented. Because of the unusually severe requirements of marine service this account of drives which have successfully met the extreme conditions will be of particular interest to designers concerned with power transmission and control.

Fig. 1—Below—Opposed pistons effect balance of gas pressure and inertia forces in marine diesel engine. Scavenge air enters lower ports, exhaust leaves through upper ports. Structure is of welded steel plate design



Direct-Connected Engines

By G. McConechy
Chief Engineer
Sun Shipbuilding & Drydock Co.

DESPITE the era of speed through which we are now passing, the slow-speed direct-connected diesel engine holds an important place in the present shipbuilding program. These engines are of rugged design and if given moderate attention and periodic overhaul will survive the hull of the vessel in which they are installed. Speed of the direct-connected engine is usually determined by the most efficient speed of the propeller, which generally varies from 70 to 100 revolutions per minute for single-screw vessels and 125 to 130 for twin-screw ships.

Engines are of the single-acting, double-acting or opposed-piston types and may be either two cycle or four cycle with normal scavenge air system or with supercharging. Fuel system is of the pressure atomizing type, air atomizing systems having been discarded for more recent installation. Modern marine diesel structures are of welded steel plate design, with main bearing housings of cast steel welded into the frame structure. Using welded design and raising the operating speed from 70 to 90 revolutions per minute have greatly reduced the weight of the engines for a given output, a feature which must be considered in

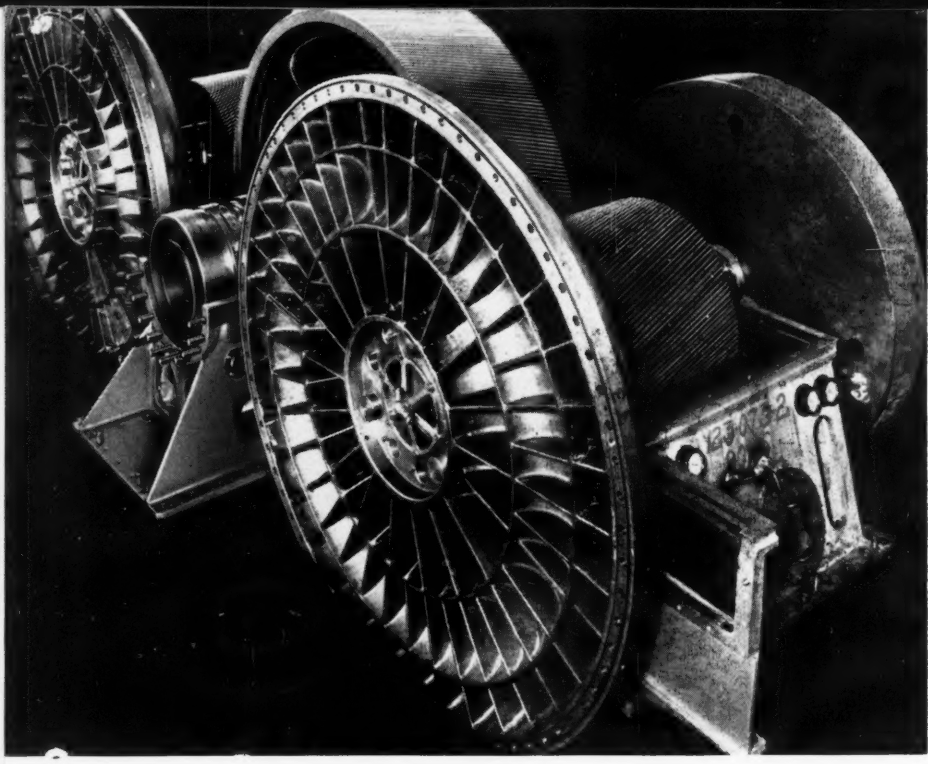


Fig. 2—Left—Reduction gear for a C-2 ship transmits power from two 3000-horsepower engines to a single propeller. Hydraulic couplings connect engines with their respective pinions

the design of a modern ship.

A brief outline of the design of a highly successful American-designed engine should be of considerable interest. Illustrated in *Fig.* 1, this engine is of the opposed-piston type and has been manufactured and installed in units of from three to six cylinders with and without attached scavenging pumps. The structure is practically one hundred per cent welded design.

Unequal Strokes Aid Inertia Balance

Two pistons operate in an open-ended water-jacketed liner in opposite directions vertically about the combustion chamber. The lower piston is connected through a conventional crosshead and connecting rod to the center throw of a three-throw per cylinder crankshaft. Top piston is connected to a transverse beam actuating two side rods the lower ends of which are attached to crossheads and connecting rods which in turn are connected to the crank throws on either side of the center throw. By this arrangement the compression and combustion forces are taken up by the connecting rods, side rods and crankshaft, the only load on the main bearings being the static load of the reciprocating parts. To balance the inertia loads of the upper piston due to the greater weight of the two side rods, two crossheads and two connecting rods, the stroke of the side cranks is made shorter than that of the center crank.

This type of engine has been installed in sizes varying from 13 inches diameter by 39 inches combined stroke to 32 inches diameter by 95 inches stroke, ranging from 750 to 8250 shaft horsepower continuous rating. The new welded construction has considerably reduced overall weight, the 32-inch diameter engine with five cylinders and attached scavenge pump weighing about 1,342,000 pounds. This engine has a normal rating of 7500 shaft horsepower at 94 revolutions per minute, and at sea showed an overall fuel rate of .3695 pounds per shaft horsepower per hour including 190 kilowatts electrical load from diesel-driven generators.

Four navy vessels have been equipped with two opposed-piston engines of this type delivering 8500 total shaft horsepower to the single propeller shaft through reduction gears and electric couplings. Each engine has six cylinders 21 inches diameter by 60 inches combined stroke and turns at 180 revolutions per minute, the propeller speed being 85 revolutions per minute. Engines of this type are capable of carrying a 25 per cent overload for two hours.

Geared Drives

By B. V. E. Nordberg
Executive Engineer
Nordberg Manufacturing Co.

NUMEROUS diesel installations with reduction gear drive, including a long list of ships built abroad to make use of existing high-speed engines, give ample proof of the practicability of the reduction gear drive. The Maritime Commission requested the use of such drives in some of the C-1, C-2 and C-3 ships and many of these ships are now in service.

For the C-2 ships the requirements called for 6000 shaft horsepower at normal load on a single propeller running at 92 revolutions per minute and 6600 shaft horsepower available for continuous operation. A two-hour peak load of 7500 shaft horsepower also was specified. One group of C-2 ships is equipped with two engines running 225 revolutions per minute connected to a single reduction gear through hydraulic couplings, *Fig.* 2. They are nine-cylinder, crosshead-type, two-cycle engines, having cylinders 21-inch bore by 29-inch stroke and equipped with a gear-driven blower mounted on the engine. Weight of this complete unit, including gear sets, couplings, thrust bearings, and engine is about 616,000 pounds. The first of the ships has by this time covered more than 135,000 miles. Its service has been unusual, as it supplied our front lines.

Reduction Ratio Is 2.4 to One

For the C-1 ships, the requirements called for 4000 shaft horsepower normal load, with a continuous top rate of 4500 shaft horsepower and a two-hour peak of 5000 shaft horsepower, normal propeller speed being 92 revolutions per minute. In one set of these ships, two trunk-piston type engines having six cylinders of 21½-inch bore by 29-inch stroke, running 220 revolutions per minute normal speed, were interconnected by a set of gears driving the single screw, there being an electric coupling between each engine and gear set. This engine has a direct-connected reciprocating scavenging pump.

In some of the C-3 ships, four diesel engines coupled to a single propeller shaft turning 85 revolutions per minute were installed, with electric couplings between the engines and gear set. The main engines are rated 2250 brake horsepower at 240 revolutions per minute for normal load

and are capable of maintaining 2450 brake horsepower at 247 revolutions per minute, with a two-hour peak load requirement of 2780 brake horsepower.

Advantages of a diesel engine with gear reduction are low cost, low weight and minimum space requirements. The engine lends itself to manufacturing production and one type of development may suit several types of ships; thus the same engine development has answered for the C-1, C-2 and C-3 ships. The same advantages extend to operation and maintenance, although the additional equipment in gears and couplings adds some complication.

As a damping device the slip coupling is essential to the high-speed diesel engine. Its adoption with the gear drive and two or more engines also adds flexibility in providing use of at least one engine in case of trouble, while the improved maneuvering qualities have surprised even the well informed.

Losses Are Compared

Comparison of the geared unit with direct drive brings up the question of losses. These losses, including slip in the couplings and friction in the gear set, are never serious. The gear set loss is estimated to be 2 per cent including the thrust bearing, and the slip varies from 2.48 per cent to 2.75 per cent as determined by tests of several hydraulic couplings. Added to this is the power consumption, for furnishing makeup oil, and leakage, which was determined to be 160 gallons per minute at a pressure of 28 pounds per square inch. The circulating pump is motor-driven and with its losses adds about .2 per cent to the slip losses, resulting in an average overall slip loss of 2.75 per cent.

Test of an electric coupling indicated a slip of 1.21 per cent. Energy supplied to the electric coupling was 19.8 kilowatts, generating losses which must be charged to the coupling as the power is developed on board ship. The line loss from the generator to the switchboard and to the coupling may be estimated to be 2 per cent; the generator efficiency 92 per cent, and the fuel consumption of the auxiliaries as compared with the main engine is as .42 is to .38, which results in 32.6 brake horsepower loss. This amounts to 1.58 per cent which, added to the slip, gives a total of 2.79 per cent. Its losses therefore are approximately the same as in a hydraulic coupling, and while it entails considerably more complication, it nevertheless has the advantage of quick action.

All of the diesel engines used in the C-1, C-2 and C-3 ships are directly reversible. In a direct-coupled job the number of reversals becomes exceedingly large at times and has a direct bearing on the life of the engine. Engines with reduction gears may be independently disconnected from the gear set and with one running forward and the other astern it is possible to connect either engine at will to the propeller shaft by energizing the electric couplings as required to effect reversal of the propeller shaft. Only partial loads are, of course, available, but this is ample in a great majority of the telegraphic orders received in the engine room. The control is so arranged that both engines may be handled as a single unit.

Hydraulic Couplings

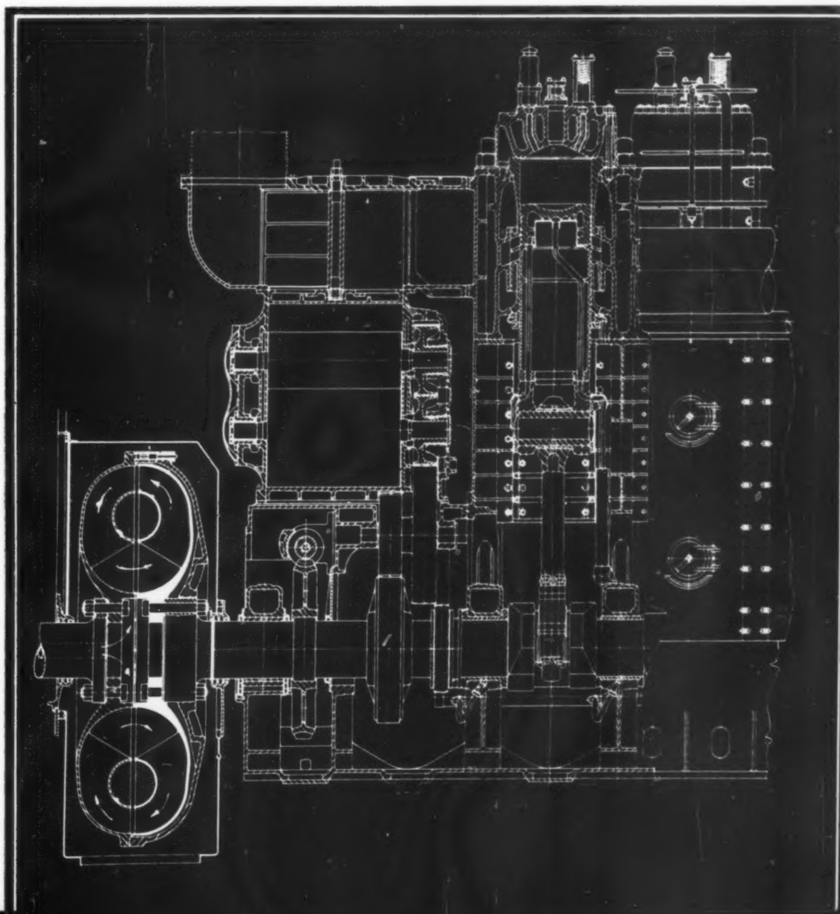
By R. G. Olson
Hydraulic Coupling Division
American Blower Corp.

ALTHOUGH the hydraulic coupling serves several functions in connection with geared diesel installations, it is used primarily because of its ability to transmit power efficiently without transmitting torsional vibrations. Because of the absence of physical connection between the primary and secondary rotor, the vibrating system of the diesel engine is completely divorced from the reduction gear unit, propeller shaft and propeller. As a result, the uneven torque of the engine is converted into completely even torque on the output shaft, and the same rules can be followed in designing helical gearing and propeller shafting as are used for steam turbine drive. When two or more engines supply power to a common service, no special provision for synchronizing the speeds of the engines is necessary.

Aside from the function of torsional vibration damping, the hydraulic coupling serves the following purposes:

1. Protects the engine and gears from damage due to sudden shock loads which might result from a seized piston or fouled propeller.
2. Permits convenient clutching and declutching so that when repairs are required at sea in the case of multiple-engine installations, an engine can be taken out of service by simply emptying one of the couplings, while the ship continues under way on the remaining engine. Single

Fig. 3—Below—Section through hydraulic coupling and portion of 3000-horsepower engine. To declutch, valves in periphery of rotor housing are opened, permitting oil to escape



engine operation can also be used to advantage when it is desired to operate the vessel at reduced speed for extended periods.

3. Permits engines to be operated in port for warming up and adjustment without being connected to the propeller shaft.
4. By partially filling the coupling, low propeller speeds can be obtained, thus providing increased protection for the propeller when operating in ice or in shallow waters.

The hydraulic coupling follows the same laws that govern centrifugal pumps in that the power varies as the cube of the speed and the fifth power of the diameter. As the power-transmitting capacity of the coupling varies as the cube of the speed, it follows that in a vessel where the propeller characteristics conform to the cube law the slip will be constant for all engine speeds.

Effect of Overloading Coupling

Assuming constant revolutions per minute the slip of the coupling in the range from zero to about 6 per cent slip is directly proportional to the transmitted torque; consequently, in the case of a twin engine installation, if the slip of the couplings is 2½ per cent when driving the propeller with two engines, the slip will be 5 per cent when only one engine is in service.

Fig. 3 shows a section through the engine and hydraulic coupling used in a C-2 ship. It will be seen that the primary rotor of the coupling (solid portion) is connected to the engine crankshaft flange, while the secondary rotor (shaded portion) is bolted to the pinion shaft. The rotor housing (also shaded) is bolted to and rotates with the secondary rotor. This member encloses the back of the primary rotor and is for the purpose of retaining the working fluid.

Coupling Fluid Supplied by Pump

Oil is delivered to the coupling through the hollow pinion shaft (on the left) by means of a motor-driven or engine-attached pump. With the engine running and the coupling full of oil the primary rotor acts as a pump, imparting kinetic energy to the fluid which then drives the secondary rotor as a turbine. The oil flows outward between the vanes of the primary rotor, and inward between the vanes of the secondary rotor, forming a continuous vortex ring as indicated by the arrows. The secondary rotor always runs at a speed slightly below that of the primary, the slip being between 2 and 3 per cent, and it is the difference in centrifugal force resulting from this difference in speed that causes circulation between the two members.

A small amount of cooling oil leaks out continuously at the periphery of the coupling, this being caught by the stationary housing and drained back into the sump tank. When it is desired to declutch, a series of piston valves at the periphery of the rotor housing is opened by air or oil pressure and there is rapid escape of oil from the coupling circuit. At the same time the valve in the oil supply line to the coupling is closed.

Fig. 2 shows the reduction gear and secondary rotor assembly with the top half of the gear housing removed. How four engines are grouped for driving a single propeller is shown in *Fig.* 4.

Electric Couplings

By James A. Wasmund
Marine Engineer
Westinghouse Electric & Mfg. Co.

ELECTRIC couplings transmit torque by means of electromagnetic forces, there being no mechanical contact between the driving and driven members. During the past three years, the Maritime Commission has put into service a large number of vessels propelled by diesel engines connected to reduction gearing through electric couplings ranging from 4375 horsepower at 180 revolutions per minute with an outer diameter of 115 inches, to 1170 horsepower at 350 revolutions per minute, 69½ inches in diameter. All are of essentially the same construction.

Some of the advantages obtained by the use of electric couplings for ship drive are as follows:

1. A number of engines may be used to drive a single propeller, and any engine or engines may be instantly connected or disconnected from the propeller shaft by operating a switch to close or open the coupling field circuit.
2. Space and weight are saved because the use of reduction gears permits the use of relatively high speed diesel engines.
3. Diesel engine vibrations are reduced to practically negligible magnitudes in the gearing.
4. The maximum torque through the coupling is limited to approximately 150 per cent of normal engine torque. If for any reason an engine seizes, the coupling will slip

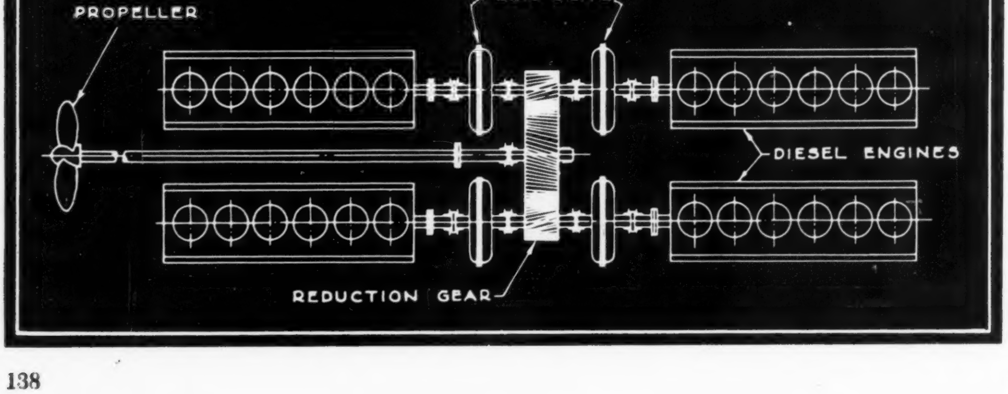


Fig. 4—Typical layout of four-engine marine drive. Either fluid drive or electric couplings may connect engines with reduction gear

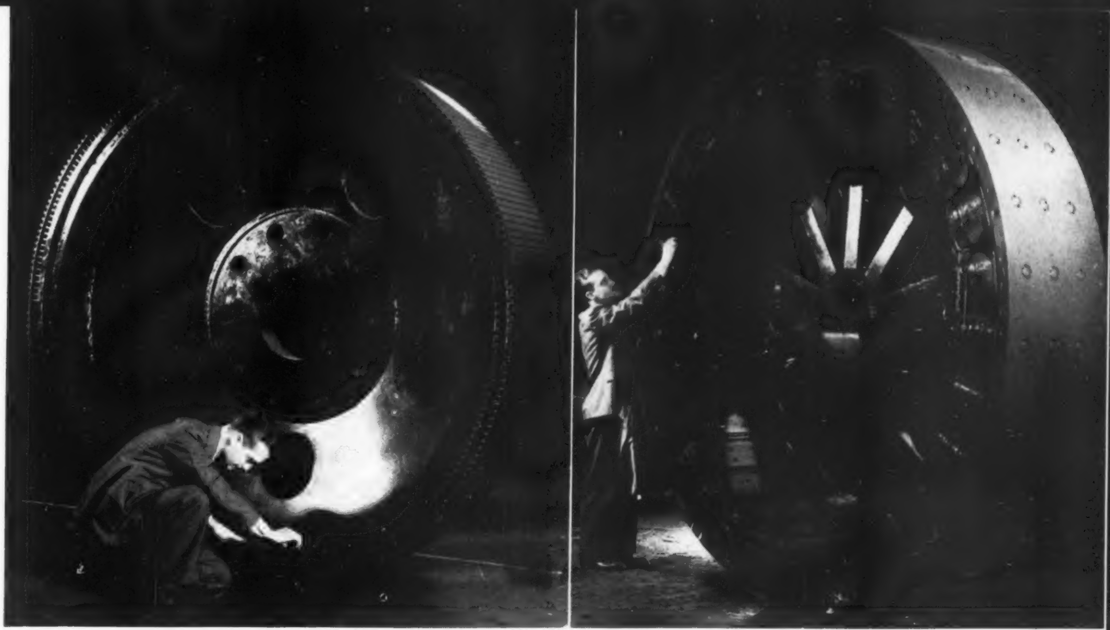


Fig. 5— ***Outer member,*** *right,* ***of electric coupling carries direct-current-excited field poles; inner member,*** *left,* ***carries squirrel-cage winding. Either may be the driving unit***

and not permit the remaining engines to damage it or the gearing.

5. The electric coupling permits maneuvering by running one-half the engines in an ahead direction, one-half in an astern direction and alternately exciting couplings connected to these engines.
6. Since the coupling members are separated by an air gap there is no mechanical contact and no wear.

Employment of electric couplings as disconnecting clutches is especially useful in multi-engine ships. The usual procedure when near a dock or when maneuvering in a close channel is to run half the engines ahead and half astern. The ship can be maneuvered in either direction simply by operating a single lever which applies field to the proper couplings, thus connecting the propeller to either the ahead or astern engines as required. All speeds except "Full Ahead" or "Full Astern" can be obtained without reversing the engines and without the use of any starting air as the engines run continuously in one direction.

The couplings also permit any engine to be shut down for adjustments without having to stop the remaining engines. At the completion of the work the coupling is energized again, it cranks the engine and the engine is back in service immediately.

Provides Mechanical Rotation of Field

The electric coupling consists of two fabricated steel spiders, rims and flanges, *Fig.* 5. On one rim, usually but not necessarily on the inside of the outer one, are bolted a number of field poles which are excited, through collector rings, from a direct-current source. In the larger sizes the field coils are constructed of edge-wound copper strap while the smaller coils are wound with insulated wire. On the other element a laminated core, surrounding the rim, carries a double-deck squirrel-cage winding similar to that of the squirrel-cage induction motor. The two elements are so constructed that one rotates inside the other, the two being separated by a small uniform air gap. Either of the two elements may be connected to the engine crankshaft flange and the other to the gear pinion flange. In most cases it has been found desirable to connect the inner element to the engine because it represents less overhung weight on the crankshaft bearings; however, in special cases where it is desired to utilize the greater flywheel effect of the outer element, this member is connected to the engine shaft.

The fundamental principle of the electric coupling is as old as the alternating-current generator and motor, both of which it resembles. The transmission of torque from the driving element is similar to that of the squirrel-cage induction motor, except that the rotating magnetic field—in the case of the electric coupling—is produced by actual mechanical rotation of a constant direct-current-produced field rather than being set up in a stationary magnetic frame by polyphase alternating current, as it is in an induction motor.

Meet High Starting Torque Requirements

In order that the electric coupling may be used for maneuvering a ship, it must be able to produce relatively large amounts of torque at high slip. Maritime Commission specifications require the coupling to produce at least 150 per cent pull-out torque as well as a minimum of 75 per cent normal torque up to 140 per cent slip.

The double-deck rotor bar construction is used to produce high torque at extremely high slips, such as occur during reversal and starting the propeller from rest. When the slip is high the induced voltage is at high frequency and the high reactance of the deep bars causes the current to be forced to the outer high-resistance bars. Since the reactance of the outer bars is small compared to their resistance, the power factor is high and resultant torque high. When operating at normal slip the frequency is low and the major portion of the current flows in the inner or low-resistance winding, resulting in high transmission efficiency.

It is feasible to design an electric coupling which may be used to adjust the speed of the driven load with a constant-speed prime mover. This can be done by using a wound rotor brought out to slip rings and external adjustable resistance. However, the efficiency of transmission is reduced in direct proportion to the speed reduction, making this means of speed control unattractive except where small amounts of power are involved.

The electric coupling has filled a definite need in the application of high-speed engines to ship propulsion and will undoubtedly find favor in other applications where similar characteristics are required.

Standardizing

Engineering Drawing Sheets

By Frank P. Kuhl

Chief Draftsman, Consolidated Edison Co. of N. Y., Inc.

WHERE a quantity of engineering drawings is used, imprinted sheets represent a definite saving in hand work. To determine the most economical sizes and a method of indicating changes and revisions, a study of existing practices was made.

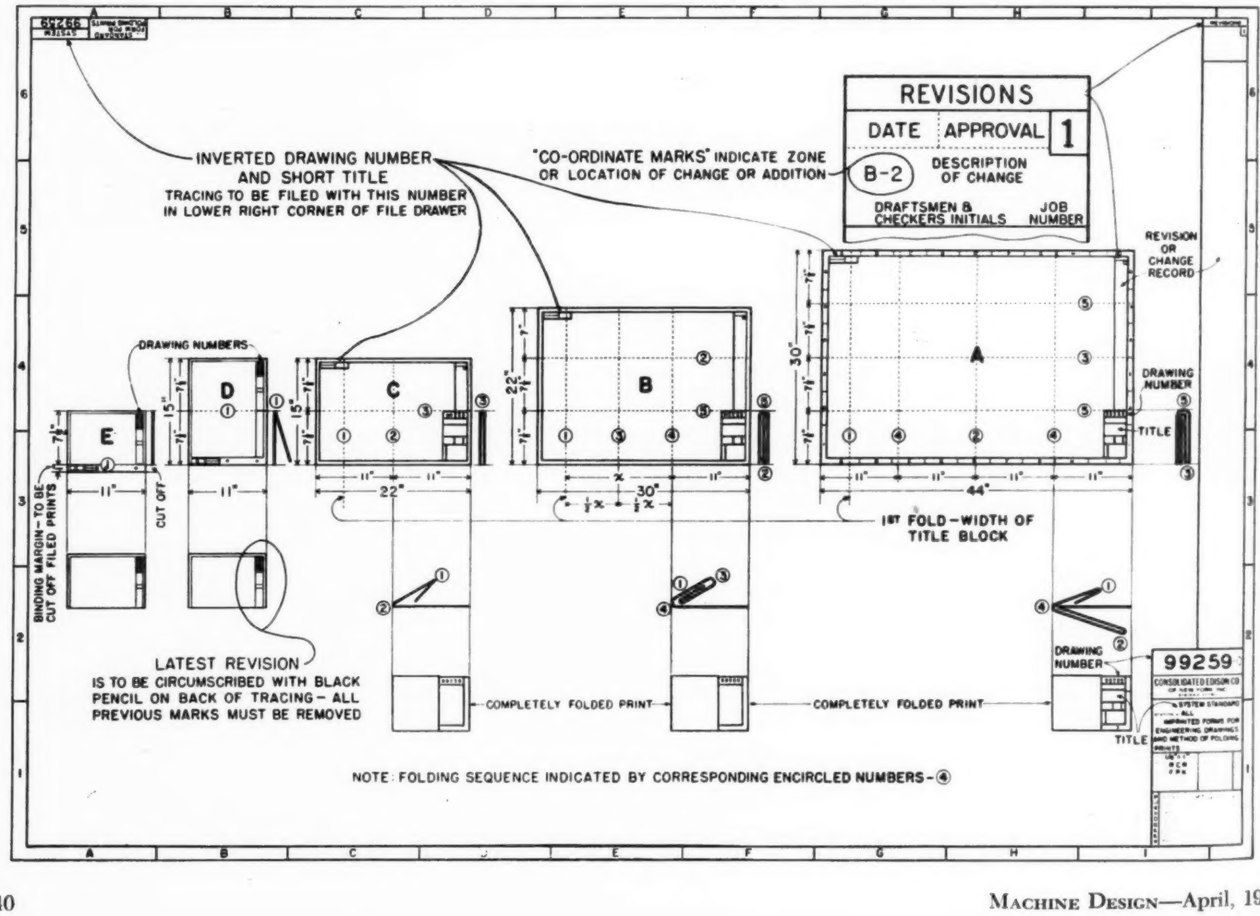
This study indicated that the standard letter size of 8½ by 11 inches might be used as a basis for determining sheet sizes. Multiples of 8½ by 11 inches, however, did not prove economical, as the widths of standard rolls of tracing cloth, tracing paper, blueprint paper, etc., progress in multiples of six inches, usually beginning at 24 inches. On this basis, a 34 inch wide sheet would have to be cut from a 36 inch wide roll, wasting 2 inches. A roll 30 inches wide resulted in a series of 30 by 44, 22 by 30, 15 by 22, 11 by 15, and 8½ by 11. Final folding size of prints is 7½ by 11 inches, which is suitable for filing in letter-size cabinets, together with correspondence.

Each sheet is provided with two title blocks as shown in the drawing, the main block being placed in the lower right-hand corner. The auxiliary block, placed in an inverted position in the upper left-hand corner, contains only the drawing number and a short title for filing purposes. Drawing number in the main title block is located so that it appears on the front of a folded print in the upper right-hand corner with title immediately beneath it.

Revision or change block is at the extreme right of the sheet, running from the top to the main title block. This location makes it unnecessary for the draftsman to rest his hand on the body of the drawing while making notations and avoids soiling from perspiration. It further allows an engineer to study a number of revised tracings, stack them in a sheaf, and sign them without danger of blotting.

To eliminate the arrow and number method of indicating changed areas, the border line around the drawing is subdivided into coordinate zones identified vertically with numbers and horizontally with letters. The coordinate marks, locating zone in which a change occurs, are noted in the revision block together with a description of the change. To simplify still further the finding of a change, the affected area is circumscribed on the back of the tracing with a heavy pencil line which at all times indicates the latest revision. Each change or revision is identified by either a letter or number which follows a dash placed after the drawing number. Letters indicate an issue of prints made while the drawing is in the development stage while numerals indicate changes after the drawing has been issued.

These details, while seemingly inconsequential, add much to the appearance and better use of the products of the drawing room while simplifying the eventual handling of prints.



Electronics Forges Ahead!

By Raymond F. Yates

BECAUSE of their versatility and their possibilities for further development, electronic controls are becoming increasingly important in war-stimulated industries. Although many of the advancements made under the impetus of military necessity cannot be discussed, recent research has resulted in covering much new ground in relation to machine controls.

Conditions to which electronic devices may be sensitive and to which precise control may be applied embrace practically all fields of design from light-sensitive units to large welders. Being essentially and primarily energy controllers, electronic tubes are classified broadly according to the following functions:

1. Energy transformation
2. Trigger or grid action whereby large volumes of controlled energy may be released by small initial impulses
3. Energy conversion where one form of energy may be transformed into electric current, then modified, etc.

Control by electronic tubes is flexible and convenient beyond other means. Their sensitivity to minute impulses and capability of handling large amounts of power makes possible almost unlimited application.

The accompanying chart tabulates information concerning all of the industrial tubes save the smaller ones usually used at the point-of-control stimulus as pure energy amplifiers. It is these tubes that amplify the small initial stimuli and in many instances are employed with the tubes listed in the chart. Often, however, they are used without any of the tubes covered by it. For instance, a pin-hole detector for the manufacture of rubberized sheeting employs a 6J7 and a F617 tube. A hydraulic flow indicator, *Fig.* 1, utilizes two FG81's only, and a liquid level indicator employs a No. 56, 45 and FG81. The 2A6 tube is one of a number that may be used to amplify the current from phototubes or photoelectric cells. Such amplifiers stand between these tubes and Thyratrons.

Other than the phototubes and the cathode ray devices tabulated, the chart is devoted wholly to the heavier types of tubes capable of handling large amounts of energy. In addition to the tubes recognized by the chart, there are nearly 400 different vacuum and gas types. Many of these may be applied industrially with or without association with those in the chart although a large number are

Industrial Power Tubes

...t	Electrical Energy																Light
...put	Electrical Energy												Light or Radiant Energy		Electrical Energy		
...tron ...ce	Heated Cathode (Thermionic)							Pool Cathode			Cold Cathode		Thermionic Cathode		Photo Cathode		Metallic Contact
...rol ...hod	Without			Electro-Static		Electro-Magnetic		Without	Static	Igniter Elec.	Without	Static	Static	Electro-Magnetic	Light		
...ce ...dition	High Pressure Gas	Low Pressure Gas	Vacuum	Vapor or Gas	Vacuum	Vapor or Gas	Vacuum	Vapor Only	Vapor Only	Vapor Only	Gas	Gas	Vacuum	Vacuum	Gas	Vacuum	Metallic
...e	Tungar Rectigon	Phanotron	Kenotron	Thyratron	Pliotron	Permatron	Magnetron	Pool Tube	Grid Pool Tube	Ignitron	Glow Tube	Grid Glow Tube	Cathode Ray	Cathode Ray	Photo Tube	Photo Tube	Barrier Cell
...ifier ...tch																	
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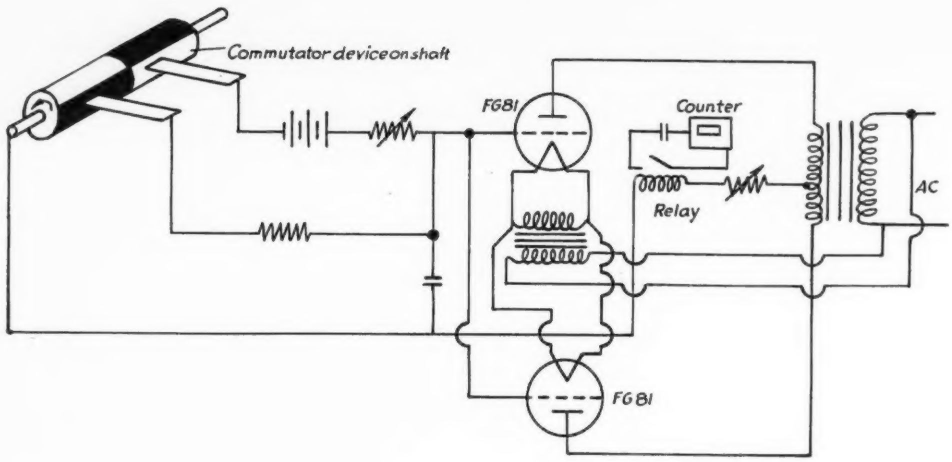


Fig. 1—Hydraulic flow indicator utilizing two electronic tubes. Counter functions only when commutator speed is below normal

employed exclusively in radio engineering.

Some potential users of tubes are confused by the various names for tubes and their functions. The matter, however, may be simplified as indicated in the chart. First, rectifier or switch-type tubes have the thermionic or heated-filament type of cathodes. These may be simple, two-element tubes with either gas or vacuum as, for instance, the Tungar, Rectigon, Phanotron or Kenotron. Such tubes are provided with no means for controlling the unidirectional current flow.

The Thyratron is a gas-discharge tube in which one or more electrodes (it has four) may electrostatically control the starting of the unidirectional current. The Pliotron is similar to the Thyratron save that the envelope is thoroughly evacuated and is electrostatically controlled. Both the Thyratron and the Pliotron may also be used as control rectifiers, amplifier oscillation generators or inverters.

As might be surmised from their names, the Permatron and Magnetron are magnetically controlled. The Permatron is either gas or vapor filled and may function as a rectifier or switch. The Magnetron is evacuated and functions *only* as a rectifier or switch. The Ignitron is a power tube of the gas-discharge type in which an ignition electrode is used to control the starting of the unidirectional current flow in each operative cycle.

Aside from a wide range of photo-responsive tubes, there are other highly specialized tubes but the above outline treats the major and most widely used devices.

Is Most Promising Power Tube

Many are the uses for Thyratrons, perhaps the most promising of the power-control group. They have found wide application in the welding industry, both for automatic arc welding and resistance welding. This tube also is useful for the control of direct-current motors.

Generally speaking, the equipment consists of an adjustable-voltage rectifier using Thyratron tubes to supply the direct current for the field and armature of the motor. By varying the output voltage of the tubes the speed of the motor can be changed. Some type of feed-back system is employed to do this, and it may be of either the mechanical or electrical type.

The phase-shift method is one of the common ways to vary the output voltage of a Thyratron tube. This employs the use of a resistance-reactance bridge which permits the phase relation of the grid voltage to be varied with respect to the anode voltage. By varying one of the elements in the bridge circuit, it is possible to change the phase displacement of the grid voltage with respect to the anode voltage from a condition where the two are completely in phase to the point where they are 180 degrees apart. When the two voltages are completely in phase, the tube will be full on. When they are completely out of phase, the tube will be completely off and will not conduct current. By varying the voltage relation between these limits the tubes can be turned to any desired degree.

In a mechanical feed-back system, one of the elements in the phase-shifting bridge—usually the reactor—is varied mechanically to change the output of the tubes and thus regulate the speed of the controlled motor.

Close Speed Regulation Obtained

Experience with the type of equipment previously described has resulted in the development of the Thy-mo-trol system. In combination with a suitable motor, it provides a variable-speed drive with features which are not ordinarily found in other types of drive.

This electronically controlled motor was not developed to supplant the various other types of mechanical and electrical drives in use today where such drives have the proper characteristics and provide all the features needed. Instead the control has been developed to evolve an electronic drive providing features not inherent in conventional drives, especially where close speed regulation, smooth acceleration, precise control of speed, and other similar features are desirable.

Briefly, the new control does these things: It permits the use of an ordinary shunt-wound direct-current motor from unfiltered rectifier supply; varies the accelerating torque so that the motor may be brought to operating speed consistent with its load in the shortest possible time; presets the speed at which the motor will operate; offers protection against sustained overload, wide speed range and close speed regulation.

It must be set down that this control reaches far beyond the conventional electronic types offered a short time back. As a case in point, the control placed on a planetary milling machine might be mentioned. After button starting, the control feeds the milling cutter into the work at a preselected speed and a few seconds later automatically

switches to another preselected speed for an "off-cutting" period. There is rapid reversal of the motor at the end of the operation and automatic shut down at the end of the cycle. Such a control is illustrated in *Fig.* 2 for the direct-current feed motor on a machine for milling airplane spars. Another similar application is shown in *Fig.* 3 where a built-in Thy-mo-trol panel controls a form and thread milling machine.

Some thought is now being given to the matter of machine control through the agency of an electronic tool pressure gage. General Electric has developed a simple gage for use in the accurate determination of the best shapes for cutting tools, rate of feed, depth of cut and machinability of materials. It would appear that the termination of this research, which has been greatly stimulated by war needs, would point the way to direct electronic control of cutting tools so that all cutting operations may be conducted at speeds just under prohibitive critical points with indicators for degrees of tool sharpness, etc.

Under the pressure for higher production, the aircraft manufacturers have turned to electronic control and inspection. Unfortunately discussions of some of these applications must await more trusting times. However, it can be said that dynamic balancing of crankshafts, impellers and other rotating parts has been tremendously accelerated by electronic apparatus. The systems have been simplified to a point where unskilled operators may use such equipment.

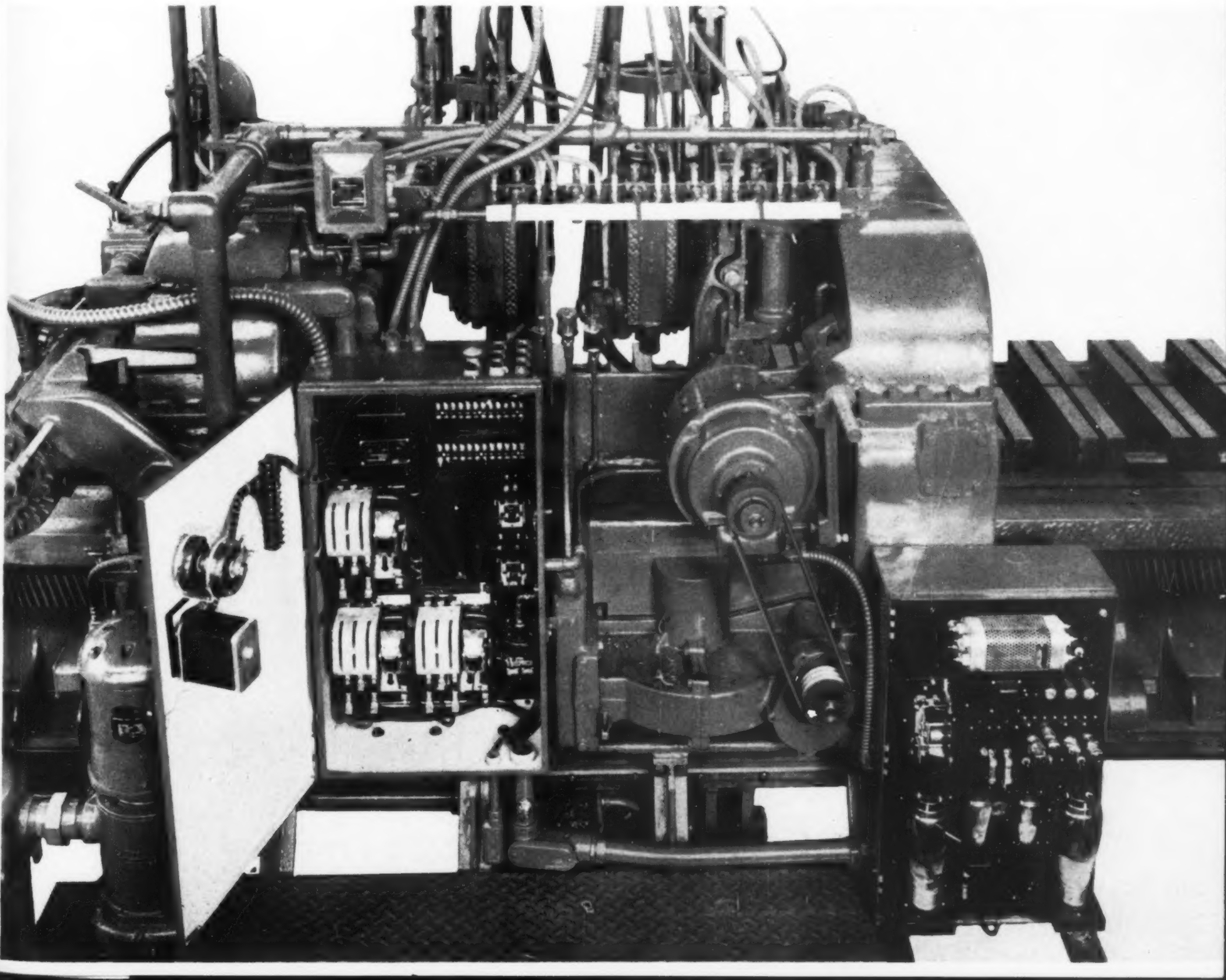
There has also been an increased use of stroboscopic equipment for inspection and of piezo crystals for the measurement of vibration. Laboratory determinations of much value have been made possible with actual vibration curves plotted against time on the screen of a relatively simple and inexpensive cathode-ray tube.

Indicative of the extent to which electronics may be employed and their sensitivity to minute impulses is a "strain gage" used extensively by the aircraft designer. A dynamic type of gage, it employs a pick-up device that responds to flexing. The output of the "flexed detector" device is fed to high-gain amplifiers coupled to cathode ray oscillographs. The pick-up device itself is simple, taking the form of a fine wire of special alloy. When this wire is flexed or bent even slightly it suffers minute changes in length and cross section, causing minute changes in its electrical resistance that are instantly caught and recorded photographically on a moving tape. Also indicative are the tensiometer and electrolimit gage applied to a steel mill for controlling tension and sheet thickness, *Fig.* 4.

Testing Is Accelerated

An outstanding application of electronics was devised for testing aircraft crankshafts. It amounts to a superpower sonic system. Pure audio power, amplified to a level of about one-third horsepower, is applied to the end of the crankshaft, opposite the flywheel. This applied current "twists" the shaft first one way, then the other at any speed, offering a fine mechanism for research on

Fig. 2—Electronic unit controls the direct-current feed motor on machine for milling airplane spars



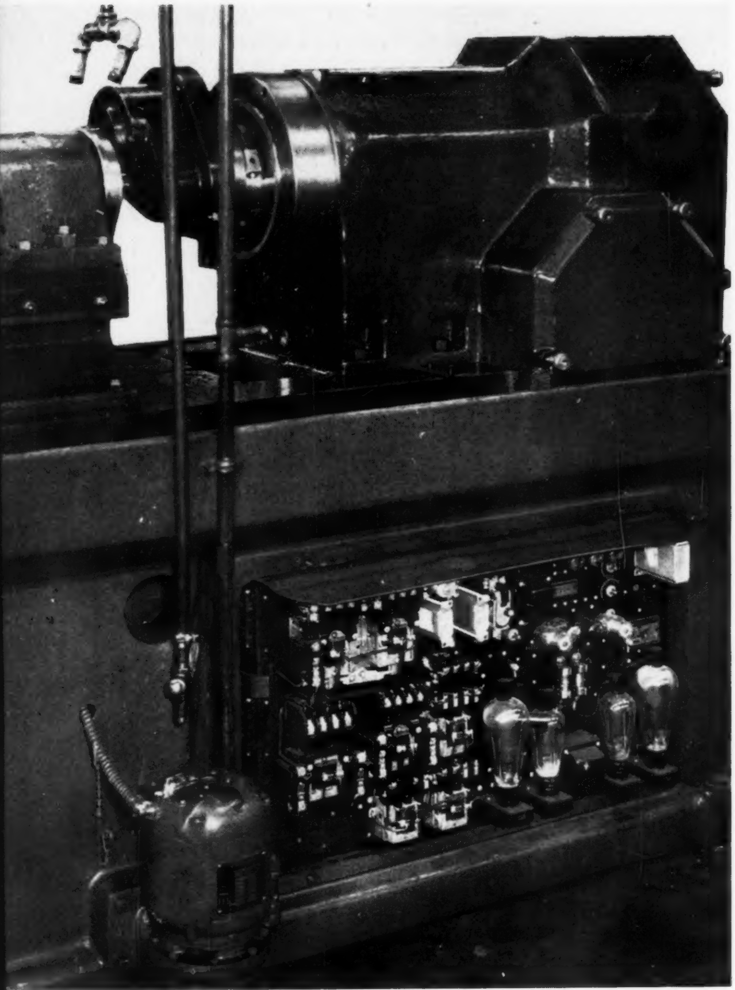
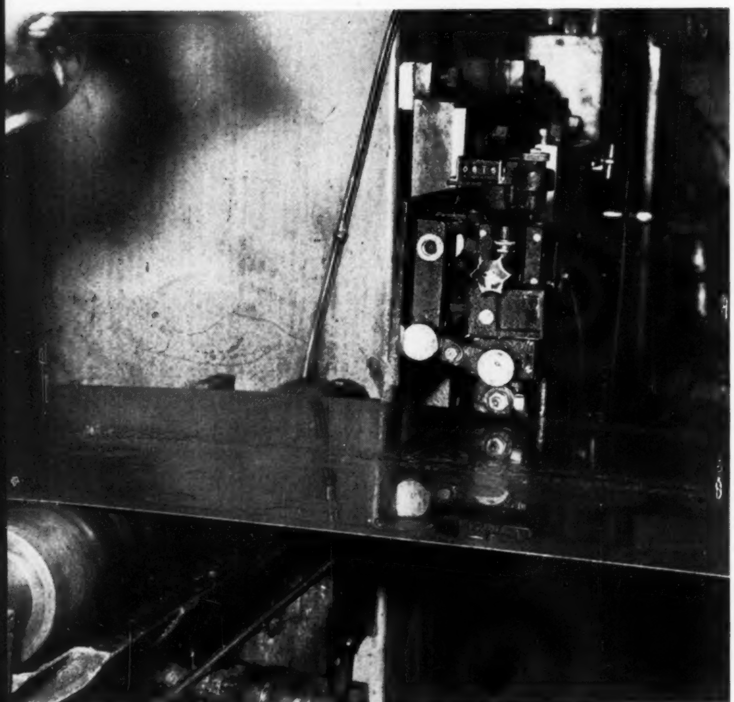


Fig. 3—Built-in Thy-mo-trol panel on milling machine

Fig. 4—Tensiometer regulates tension in steel sheet running between the stands of a tandem mill. Roll for tensiometer is shown in left foreground. Electrolimit gage in background measures thickness of strip



natural periods of vibration, etc.

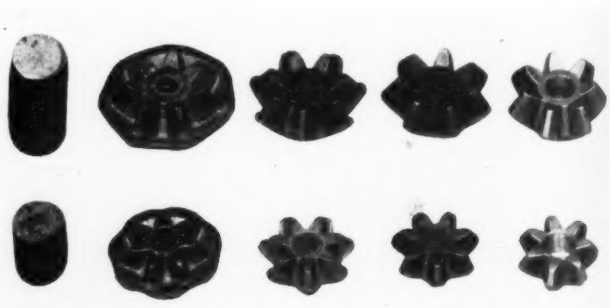
Electronic elongation recorder for L-type hydraulic testing machines weighs the load independently of the testing machine, using an electronic principle to measure the distortion of a bourdon tube by a micrometric screw. This gives an inherent linear scale and therefore a single calibration which can be retained indefinitely. The chart of the machine yields records of maximum strength, proof strength, yield strength and type of yield.

Design engineers with problems that might be solved by electronic devices will do well to investigate electronic equipment such as time delay sensitive relays, counting relays, sequence switches, magnetic contact relays, plunger type mercury contact relays, transformer relays and a host of other special types and designs made especially for electronic engineering. During the past five years especially, tremendous progress has been made in this field and while the improvements have not been revolutionary, they have succeeded in producing a reliability of performance that has been able to endure intense industrial strain.

Doing More with Less

COINED gears not only eliminate practically all machining operations but also save half the steel normally required for machined gears. Illustrated are five stages in the production of two differential pinions by this process as developed by the Timken Detroit Axle Co. At the left are the billets from which the gears are produced. Next are the rough-formed pinions after the first forging operation. Then the second forging operation before being trimmed is shown, followed by trimmed gears. At right are the finished pinions after machining.

Pinions are so well formed in every detail that only three machining operations are required to finish them after they come off the forging machine. These consist of boring a hole for the differential trunnion, chamfering the hole and finishing the back face of the pinion. The teeth require

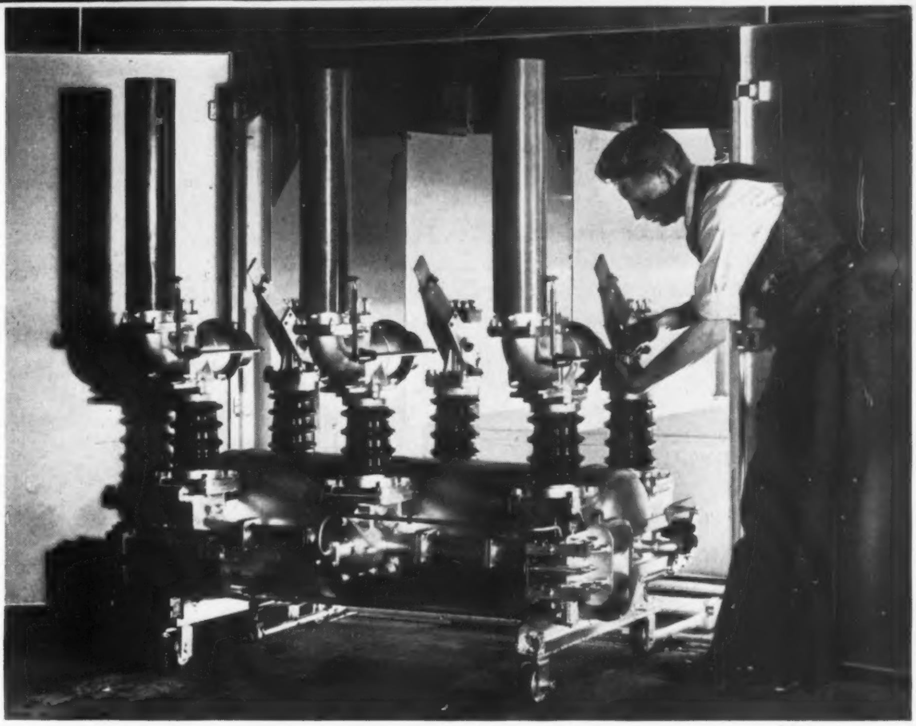


no machining whatsoever, thus releasing thousands of machine hours.

Billets for two typical pinions weigh 2.12 and .92-pound whereas those for corresponding machined gears would weigh 4.77 and 1.65 pounds, respectively. The finished coined gears are slightly heavier than machined ones because of the denser metal structure produced by the forging operations, resulting in increased strength.

Because these pinions are used in hundred-thousand lots, the savings in steel and manpower represent a sizeable contribution toward conservation in our war program.

Fig. 1—Compressed air operates contacts with maximum speed and assists in "snuffing" arc in this 500,000 kilovolt-ampere circuit breaker



By Harold W. Martin
Allis-Chalmers Mfg. Co.

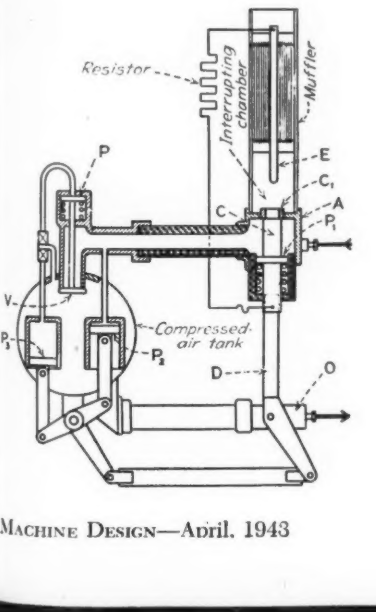
Use of Compressed Air Saves Vital Materials*

TO INDICATE the possibilities of compressed air in providing design advantages in machines, features of a new circuit breaker utilizing this form of energy will be discussed in this article. In order that problems associated with the design of this type of equipment may be presented clearly, the functions of a circuit breaker will first be outlined. Obviously, it is essential that the flow of current through a faulty point in an electric power system should be cut off with a maximum of speed and that the resumption of power should not be unduly delayed when the fault is cleared. It is in the performance of these functions that compressed air is proving of value in maintaining the flow of power to vital war industries and in preventing damage to electrical machinery such as might cause serious stoppages in war production.

In the normal 60-cycle circuit, every time a reversal of current flow takes place there are a few millionths of a second during which no current actually flows in either direction. It is during this extremely short interval of zero current that a breaker has to perform its functions. The total amounts of power which may have to be interrupted vary widely and may be as high as 2,500,000 kilovolt-amperes, equivalent to 2,840,000 horsepower. Obviously, the problem of interrupting the flow of such large amounts of power is no simple one.

When the breaker contacts separate during interruption the current continues to flow, causing an electric arc across the gap between contact surfaces. This arc

*From a prize-winning paper in a contest sponsored by the Compressed Air Institute.



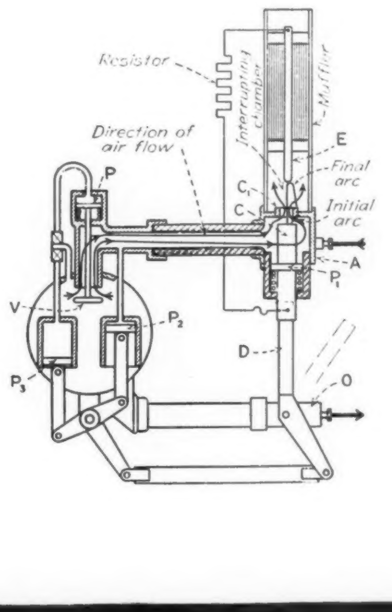


Fig. 2—Extreme Left—Closed position of breaker showing arrangement of pneumatic equipment

Fig. 3—Left—Intermediate position on opening showing initial arc and action of compressed air in extinguishing it. Dotted line indicates position of isolating contact when breaker is open

persists until the direction of current flow changes and a zero-current pause occurs. If it is possible so to insulate the contacts during zero pause as to prevent reignition of the arc when the current tries to flow in the opposite direction, circuit interruption is achieved.

In designing the breaker there are two lines of attack by which maximum interrupting efficiency may be obtained; first, by so acting upon the space between the contacts as to produce an extremely high rate of insulation build-up and, second, by limiting the rate of increase of the voltage which appears between the contacts immediately zero pause occurs and current flow ceases. The most efficient circuit breaker is the one in which the rate of insulation build-up during the first current zero after contact separation is always greater than the rate of increase of voltage (or pressure tending to cause a resumption of current flow) between the contacts. Under these circumstances reignition of the arc and resumption of current flow is impossible and the maximum period of arcing between the contacts is one-half cycle (1/120th-second). The application of compressed air to the problem has produced consistent circuit interruption of this high order for the first time in circuit breaker history.

Cooling and Turbulence Are Important

Investigations into circuit interrupting phenomena have proved that the main factors which produce a high rate of insulation build-up (dielectric recovery) between the interrupting contacts during current zero, are cooling and turbulence in the zone between the contacts. Either or both of these factors can be employed and the rate of dielectric recovery depends upon the intensity of the cooling and turbulence effects. Another factor affecting the rate of dielectric recovery is the rate of separation of the contacts.

Before the application of compressed air to the problem of circuit breaker interruption, most circuit breakers were operated by electromagnets or solenoids. A large solenoid was usually used for closing, the breaker contacts being held in the closed position by a latch. When the contacts were required to open, the latch was released by the action of a small tripping solenoid, allowing the contacts to part at high speed due to the pressure of springs which had been compressed during closing, the opening action being assisted by the weight of the movable contact structure in most cases.

Modern power systems are now frequently demanding operating speeds which are difficult to meet with solenoid-operated circuit breakers of the conventional type. These demands, coupled with the increasing necessity of conservation of vital materials required for war, such as steel and oil, have resulted in the development of air-blast circuit breakers in which the efficient use of the characteristics of swiftly flowing, expanding compressed air has produced such a high order of interrupting efficiency that arcing times, during interruption, of one-half cycle or less are consistently obtained.

A typical indoor air-blast circuit breaker, rated 15,000 volts and capable of interrupting 500,000 kilovolt amperes (600,000 horsepower) is shown in *Fig.* 1. This breaker is capable of interrupting a maximum of 45,000 amperes. It is assembled on a horizontal compressed air tank forming the foundation on which the active parts of the breaker are mounted. Air for operating the breaker and for interrupting the arcs is stored in the tanks at 200 pounds per square inch pressure, the tank being permanently connected to a compressed air storage system. The arcing contact chambers and the cooling chambers and mufflers are supported on the air tanks by hollow insulators.

A diagrammatic cross section, *Fig* 2, is shown with all parts in the closed position. The electrical circuit is through the arcing contact chamber casing *A*, stationary arcing contact C_1, movable arcing contact *C*, isolating contact *D*, to terminal *O*, as indicated. The main blast valve *V* is located in the air tank and held closed by a spring under piston *P* and by the pressure of air in the tank.

Electrical actuation of the valve, resulting from overload in the system, admits compressed air above the piston which is forced downward and opens the main blast valve, admitting air into the arcing contact chamber as shown in *Fig.* 3. When the air pressure in the arcing contact chamber reaches a value sufficient for efficient arc interruption, piston P_1 is forced downward against the upward pressure of its spring and pulls movable arcing contact *C* away from the stationary contact and air-blast opening C_1. This draws an arc between the points marked initial arc.

Because the opening in the center of the stationary arcing contact is the only outlet for the compressed air, a blast of high velocity air discharges across the initial arcing zone and through the opening to the interrupting chamber and muffler. The air blast through the center of the stationary contacts acts to centralize and extend the arc until it comes in contact with an electrode, *E*, as shown. This controls the length of the arc and helps to limit the arc energy released. The blast of air also quickly forces the arc products into the cooling chamber and muffler, thus rapidly scavenging the arc path during current zero.

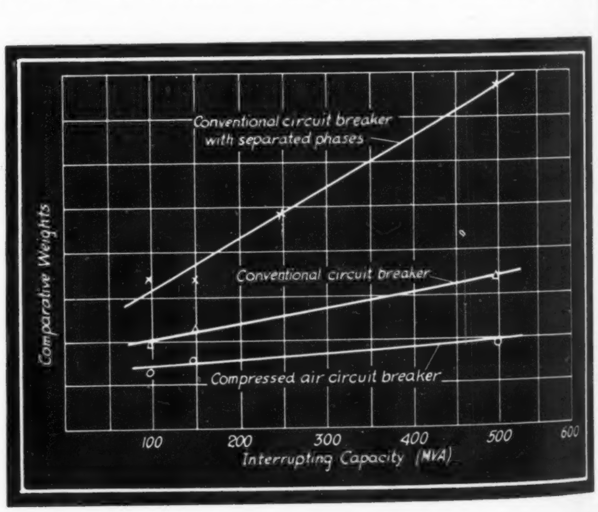
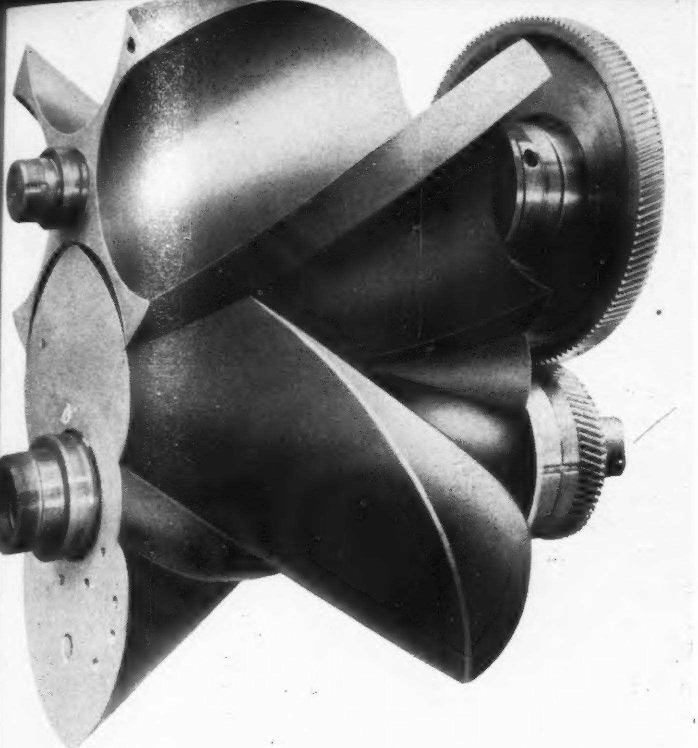


Fig. 4—Weight of compressed-air breaker compared with other units, indicating marked savings in steel and oi

It will be noted from *Fig.* 3, that the compressed air is permitted to expand suddenly as it passes upward out of the stationary arcing contact opening. This sudden expansion of the air causes intense cooling and turbulence in the arcing zone, these being the factors previously men-

(*Concluded on Page* 208)



Rotors of new blower revolve with two to one speed ratio. Profiles of the helical threads are generated by a single-point cutting tool on a special planer

Blower Design Utilizes Screw Principle

By J. E. Whitfield
Chief Engineer, Blower Design
General Machinery Corp.

DEVELOPED ***primarily for scavenging and supercharging, this new blower is in production for marine engines. In an article based on a paper presented at the S.A.E. annual meeting the designer discusses, within the limits imposed by Government regulations, the development of the blower***

IN THE development of positive pressure blowers and superchargers, much effort has been expended in reducing noise as well as increasing efficiency and mechanical reliability. A blower would appear to be a simple machine but in practice it is extremely difficult to combine high efficiency with reliability. Thus the designing engineer is always confronted with the alternatives of keeping the clearances large to insure mechanical reliability or of keeping them small to get good efficiency. He wants to make the blower large so as to keep down the noise and speed but he also wants to make it small to reduce the bulk and weight. He must build it to compete in cost with other blowers and yet he must design for a satisfactory useful life. Thus the design is a compromise and the outcome depends on the judgment of the designer.

In developing the Hamilton-Whitfield blower, discussed in this article, more than ten years were spent on various kinds of blowers before a satisfactory solution was reached. Most of these types possessed two or more of the following inherent disadvantages: Inefficiency, excessive noise, failure to deliver oil-free air, bulkiness, short life.

Attention was then turned to the screw type blower as a solution. Various designs were built and tested but it usually turned out that there was an opening connecting the intake and discharge ports, although this opening was often a roundabout path which was difficult to locate and more difficult to visualize and remedy. The result was that the early blowers made little noise and also little pressure. These blowers were not partial failures; they were complete failures. However, the present design was finally arrived at and its apparent success was immediate. While the blowers built to date do not have all the features that will eventually be included, they have already proved themselves superior to the blower they were built to replace.

Essential parts of the blower, shown in the figure, include two helically threaded rotors supported in a casing with their axes parallel, the threads being intermeshed to form a continuous sealing line for the full length of engagement. The casing encloses both rotors in such a way as to seal their perimetral edges and the only path through the blower is in the troughs of the threads. Air connections located in the casing communicate directly with these troughs and serve as inlet and discharge ports. The ports are diagonally opposed, positioned on opposite sides of the plane intersecting the axes of the rotors and formed partially in the heads and partially in the side walls.

The larger of the two rotors, known as the main rotor, carries two helical threads each extending through 180 degrees from one end to the other in a right-hand spiral. The smaller rotor, known as the gate, runs at one-half the main rotor speed and carries four helical threads each extending through 90 degrees from one end to the other in a left-hand spiral. Thread forms are symmetrical and are generated, the sides of the main rotor being described

(*Continued on Page* 214)

Designer's Achievement Is His Reward

ON every hand one hears of awards being made to companies, groups and individuals in recognition of their splendid work in the furtherance of the war program. Ranging from the Army-Navy "E" to the badge of honor bestowed on individual workers for meritorious suggestions, the awards are being created and bestowed in seemingly ever-widening circles.

Chief engineers and designers by the thousand must have felt justly proud of the part they have played in the winning of their companies' "E" awards. They have been inspired by the advances made possible through the adoption of suggestions offered by their fellow workers, primarily in the more dramatic and freely discussed production phases of the armament program. Yet up to this time no one has come forward with a suggestion for the creation of a medal of merit for outstanding design.

It does not need to be emphasized that without design and development work of the highest order, all of the success achieved in the production of American equipment and in its actual employment in combat zones would be impossible. The design profession, realizing this, takes pride in its accomplishments and can be relied upon to continue to do its part, and more, in bringing about the final defeat of enemy powers.

Drives and Controls

NO subject other than that of materials holds more for designers under present conditions than the application of modern drives and controls in machines. Though tremendous progress has been made recently in all phases of design, it is questionable whether anything can equal—speaking from a broad rather than a specific viewpoint—the strides made in employment of electric, hydraulic and pneumatic devices in the operation of both direct and indirect war machinery.

Of the older forms of drives and controls, hydraulics stands out as a method that is being utilized advantageously in practically every form of armament equipment—notably airplanes, warships, and tanks—being made today. Electronics, of the newer devices, is rapidly coming into its own and may well have reached the point, by the time peace is signed, of revolutionizing to a large extent the future development of machines.

Under these circumstances MACHINE DESIGN *has devoted this issue of the magazine primarily to applications of drives and controls, and has laid the foundation for even more intensive coverage of this phase of design as further developments arise.*

Selecting Motors and Controls for Wartime Conditions

SHOWING how to conserve strategic materials through overloading of equipment with a reduction in life expectancy, the accompanying data sheet is abstracted from the proposed guide for the selection of electric motors and motor controllers contained in a recent A.I.E.E. report. Although the original report is to be materially expanded at a later date, MACHINE DESIGN presents the information available now because of its timeliness and immediate value to designers responsible for selection of such equipment

EMPHATIC attention has been called by the war emergency to the desirability of completely utilizing the inherent capabilities of electric motors and controllers. Critical materials which they require, such as copper, iron and steel, must be conserved, therefore the smallest motor and controller that will do each job should be selected.

Practically all of the electric motors and controllers built in the United States conform to American Standards and are therefore conservative in design and have long life under varied service conditions, as well as liberal margins to meet varying loads and voltages. If, therefore, loads and service conditions are known in advance, and especially if a reduced life expectancy is satisfactory, horsepower loadings larger than the name plate ratings may be safely applied to both motors and controllers.

The following recommendations are made for determining the smallest motors which may be economically applied:

1. In applying motors, determine with maximum possible accuracy the horsepower required. This should preferably be obtained by test, or if this is impossible, by accurate calculation or careful comparison with known power requirements of similar apparatus.

2. When applying open type, alternating-current continuous-rated 40-degree Cent. motors where the motor rated voltage is maintained and where the ambient temperature is usually substantially below 40 degrees Cent., and will only occasionally, and for short periods equal or slightly exceed 40 degrees Cent., select the standard horsepower rating which is at least equal to, but not substantially more than 80 per cent of the horsepower determined in accordance with recommendation 1. (See TABLE I.)

3. When applying either an alternating or direct-current continuous-rated 50-degree or 55-degree Cent. motor, where the motor rated voltage is maintained and where the ambient temperature is usually substantially below 40 degrees Cent., and will only occasionally, and for short periods equal or slightly exceed 40 degrees Cent., select the standard horsepower rating which is at least equal to, but not substantially more than 91 per cent of the horsepower determined in accordance with recommendation 1. (See TABLE II.)

4. After selecting motors in accordance with recommendations 2 and 3, torque and operating speed should be checked to assure their adequacy. Breakdown torque of induction motors is specified by American Standards as 200 per cent of the full load torque. Actual breakdown torques may be greater than this minimum value, particularly for motors of less than three horsepower. Breakdown torque of general purpose synchronous motors varies between 150 and 250 per cent, dependent upon the horsepower, power factor, and speed. Synchronous machine applications should be checked with the manufacturers.

5. When applying open type direct current continuous rated 40-degree Cent. motors in a location where the ambient temperature is usually substantially below 40 degrees Cent., and will only occasionally, and for short periods equal or slightly exceed 40 degrees Cent., select the standard horsepower rating which is at least 87 per cent of the horsepower determined in accordance with recommendation 1. (See TABLE III) This more conservative limitation is recommended in the case of

direct current motors in order to insure reasonably satisfactory life where commutation rather than temperature will be the determining factor.

Selecting Type of Motor

Critical materials may also be conserved by properly selecting the types of motors which have the simplest mechanical and electrical design and which will accomplish the purpose for which the motor is applied. Where operating conditions permit, the following recommendations should be followed:

1. Use open type rather than splashproof or totally enclosed motors. The weight of an open motor is considerably less than any other type (see *Fig.* 1) and an open type motor rated 40 degrees Cent. will carry more load than one rated 50 or 55 degrees Cent. (See recommendations 2 and 3 above.)

2. Use higher speed motors except in those isolated cases where an increase in speed does not result in a decrease in weight. Higher speed motors are usually lighter and have higher power factor than lower speed motors and therefore draw less current for a given load. (See *Fig.* 1.)

3. Use single-speed rather than multispeed motors. Single-speed motors are usually lighter and have higher power factor and efficiency than multispeed motors and therefore draw less current for a given load.

4. Use single winding rather than two windings where multispeed motors are essential. Single-winding multispeed motors are usually lighter and have higher power factor and efficiency than two winding motors and therefore draw less current for a given load.

5. Use alternating-current motors rather than direct-current motors whenever alternating current is available and alternating-current motors are suitable. Alternating-current motors require less strategic material and alternating-current distribution systems require much less copper than would be needed for direct current.

6. Use squirrel-cage instead of wound-rotor induction motors. Squirrel-cage motors require less strategic material than wound-rotor motors.

7. Use single-voltage alternating-current motors. Single-voltage motors require considerably less cable than double-voltage motors.

8. Use voltages not less than 440 volts for alternating-current polyphase motors, one horsepower and larger. For installations requiring motors 100 horsepower and larger 2300 volts should be considered, bearing in mind the fact that 2300-volt control equipment is often more expensive and requires more critical material than control equipment which is built for 440 volts.

Use voltages not less than 230 volts for direct-current motors, one horsepower and larger.

Adherence to these recommendations will result in a considerable saving of copper and other materials required for distribution systems, switching and control apparatus.

9. Use direct-current adjustable-speed motors with as small a speed range as is practical. Motors with smaller speed ranges are considerably lighter than those with the larger speed ranges.

TABLE I

IF THE HP LOAD		SELECT
EXCEEDS	AND DOES NOT EXCEED	A.C. 40°C MOTOR RATED
.93	1.25	1 HP
1.25	1.87	1-1/2 HP
1.87	2.5	2 HP
2.5	3.75	3 HP
3.75	6.25	5 HP
6.25	9.37	7-1/2 HP
9.37	12.5	10 HP
12.5	18.8	15 HP
18.8	25.0	20 HP
25.0	31.2	25 HP
31.2	37.5	30 HP
37.5	50.0	40 HP
50.0	62.5	50 HP
62.5	75.0	60 HP
75.0	93.7	75 HP
93.7	125.0	100 HP
125.0	156.0	125 HP
156.0	187.0	150 HP
187.0	250.0	200 HP

TABLE II

IF THE HP LOAD		SELECT
EXCEEDS	AND DOES NOT EXCEED	A.C. OR D.C. 50° OR 55°C MOTOR RATED
.83	1.1	1 HP
1.1	1.65	1-1/2 HP
1.65	2.2	2 HP
2.2	3.3	3 HP
3.3	5.5	5 HP
5.5	8.2	7-1/2 HP
8.2	11.0	10 HP
11.0	16.5	15 HP
16.5	22.0	20 HP
22.0	27.5	25 HP
27.5	33.0	30 HP
33.0	44.0	40 HP
44.0	55.0	50 HP
55.0	66.0	60 HP
66.0	82.5	75 HP
82.5	110.0	100 HP
110.0	137.5	125 HP
137.5	165.0	150 HP
165.0	220.0	200 HP

Selecting Controller Size

Motor controllers are built to standards corresponding to those under which motors are built, and so normally are designed to meet the requirements of the motor with which they are used. They have built into them certain excess capacity, or safety factor, and they may therefore be overloaded to a degree without dangerous results. Such overloading will result in increased temperature of current-carrying contacts, flexible shunts, and studs, and will also increase the current which the control device must make and break. There will, therefore, be some shortening of the life of the device, particularly the life of current-carrying contacts and of arc shields, the life being roughly inversely proportional to the loading. The following recommendations are made for determining the smallest controller which may be economically applied:

1. When the size of a motor has been selected in accordance with the previous recommendations, the controller should be selected to suit the actual motor size.

2. The controller manufacturer should be advised as to the actual load the motor will drive. The controller manufacturer will then supply a controller having a rating the same as the normal rating of the motor but will supply overload coils or heaters to suit the requirements of the load.

NOTE: With the controller selected according to these conditions, the locked rotor and single-phase current protection, provided under normal rating, will not necessarily be obtained.

3. Line fuses should be selected on the basis of the rating of the motor used since locked-rotor current and full-voltage plugging current of the motor do not change with the load.

4. In the interest of long life, low maintenance, and in some cases reduction in renewal part stocks, it has been the practice in some plants to use oversize controllers. Since the necessity of conserving critical materials now outweighs these other factors the practice should be discontinued, and no controllers should be specified of a capacity in excess of the minimum available for the normal rating of the motor.

5. When controllers are built to order for a specified horsepower, buses, terminals, and wiring should not be specified in a size larger than the minimum required by the application for which the controller is designed.

Selecting Type of Controller

Further savings of critical materials may be made in connection with the selection and specification of motor control apparatus:

1. No equipment or device should be specified which could be eliminated without causing severe operating hazards. Such equipment includes indicating lamps, ammeters, volt meters and other instruments, test jacks, special name plates, special locks, and items for the improvement of appearance.

2. The practice of using a control circuit transformer in each single motor starter for voltages of 600 or less in general requires the use of more material than is required with a single transformer for a group of controllers. Where control circuit transformers are necessary, they should be mounted separately and not specifically as a part of the controller.

3. Color coding of controller wiring should not be specified unless absolutely necessary. Color coding specifications force manufacturers to carry larger stocks of wire than would be necessary if one color wire were used.

4. Controllers should not be specified to have finishes

TABLE III

IF THE HP LOAD		SELECT
EXCEEDS	AND DOES NOT EXCEED	D.C. 40°C MOTOR RATED
.86	1.15	1 HP
1.15	1.72	1-1/2 HP
1.72	2.3	2 HP
2.3	3.45	3 HP
3.45	5.75	5 HP
5.75	8.62	7-1/2 HP
8.62	11.5	10 HP
11.5	17.2	15 HP
17.2	23.0	20 HP
23.0	28.7	25 HP
28.7	34.5	30 HP
34.5	46.0	40 HP
46.0	57.5	50 HP
57.5	69.0	60 HP
69.0	86.2	75 HP
86.2	115.0	100 HP
115.0	143.7	125 HP
143.7	172.0	150 HP
172.0	230.0	200 HP

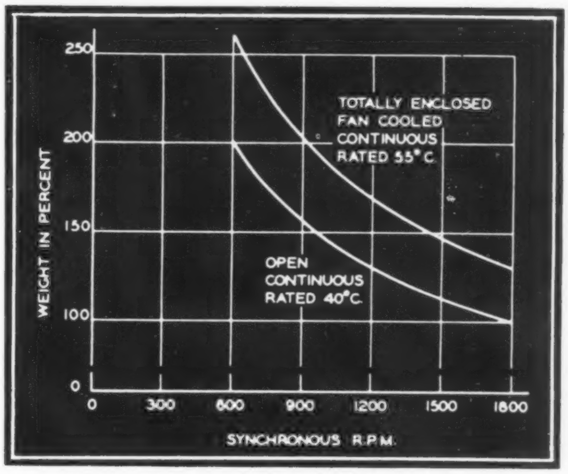


Fig. 1—Motor weight as affected by speed

which contain critical materials unless these finishes are necessary to maintain operation of the controller.

5. Full-voltage (across-the-line) starters should be used wherever possible instead of reduced-voltage (auto transformer, primary resistance, etc.) starters. The factors to check are the ability of the motor to stand full-voltage starting, the ability of the power supply to permit the inrush currents which result, and the ability of the drive to stand the starting torque and rapid acceleration.

6. Control circuit fuses should be omitted from general purpose controllers of 600 volts and less.

7. A study of the conditions surrounding a motor and control installation will often show that a considerable saving of material may be accomplished by the use of manually operated controllers instead of magnetically operated controllers.

8. Another great saving in material can be made by the use of open type controllers instead of enclosed controllers, particularly in the floor-mounted sizes. One purpose of enclosure is to provide protection to the control, by keeping out dust and dirt, and by minimizing the possibility of its being bumped and broken. Another purpose is to provide safety to workmen by preventing accidental contact with live parts. Whenever these functions can be secured by other means the enclosure should be omitted.

Expected Life

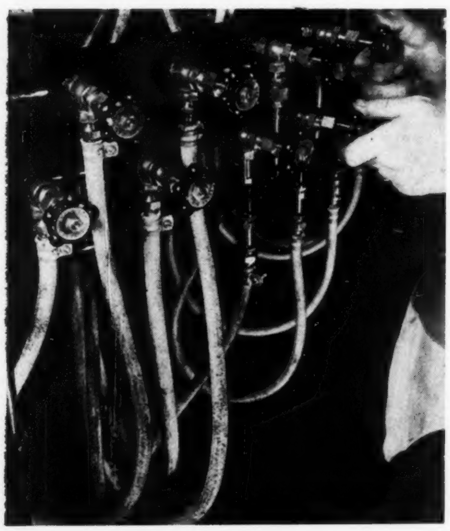
Experience has shown that general purpose motors applied in accordance with past practice have an insulation life from 15 to 20 years. It has been established that the life expectancy of these motors may be halved by operating them at the heavier loads which have been recommended in this paper. It is obvious, therefore, that as long as a safe torque margin exists the loading of these motors may be safely increased at the expense of a reasonable reduction in the insulation life. Since the amount of copper used in switches, control equipment and distribution systems is proportional to the nameplate ratings of the motors they serve, and since the weight of this copper is from two and one-half to seven times the weight of the copper in the motors, large savings in critical materials may be made by careful selection of motor and controller ratings.

Applications

of Engineering Parts and Materials

Solves Intricate Parts Problem

IN THE Link trainer a pilot learns blind flying techniques while safely anchored to the ground, his every movement being traced on the instructor's desk by an automatic recorder or crab (right). Use of die castings in the trainer itself, in the crab and in accessory instruments has reduced the number of parts required because of the ease with which intricate parts may be accurately produced. Dimensional accuracy also enables effective use to be made of die castings in compact assemblies. The trainer utilizes 118 zinc alloy die castings while in the crab the bedplate is die-cast aluminum, with bearing housings and handle of zinc. Photo, courtesy The New Jersey Zinc Co.



Replaces Rubber for Flexible Gas Lines

FLEXIBLE gas and air lines supplying moving burners on machines producing radio tubes at the RCA radiotron plant are now made of cotton-covered Resistoflex PVA hose, left, replacing rubber and flexible copper tubing. Tests show that the material conveys hydrogen, oxygen, nitrogen, illuminating gas, and air as effectively as rubber and in addition is more highly resistant to the many solvents employed in metal cleaning and other processes. Samples of the tubing have stood up for months although saturated with hot oil and subjected to continuous flexing at a rate of six hundred times an hour. The compound from which the tubing is extruded can be varied to meet the requirements of specific applications, such as flexibility and durometer hardness.

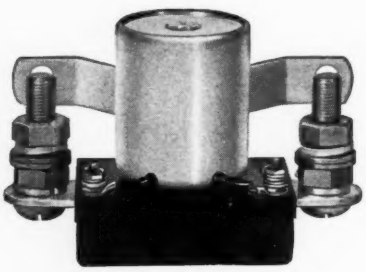
Welded Magnesium Parts Now!

DEVELOPED primarily for the welding of magnesium alloys but also suitable for stainless steels, brass, inconel, monel, etc., Heliarc welding makes possible the use of new materials for airplane parts such as the one shown at right. In this process a shield of helium gas envelops the molten metal, preventing oxidation and eliminating the use of a flux with its attendant danger of weld inclusions. Arc is produced between a tungsten electrode and the base metal while helium is fed to the weld through a specially designed torch. The new process is a joint development of Northrop Aircraft Inc. and the Dow Chemical Co. and has been successfully used on sections less than one-hundredth of an inch thick.

New PARTS AND MATERIALS

Lightweight Aircraft Contactor

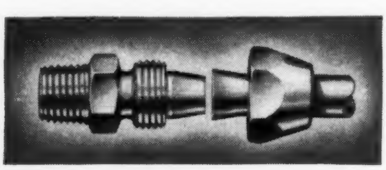
PRODUCED by Guardian Electric Mfg. Co., 1601 West Walnut street, Chicago, is a new type B-8 solenoid contactor, built to U. S. Army specifications for remote control of aircraft engine starter motors. Its function is similar to the company's Type B-4 contactor with which it is interchangeable on intermittent-duty applications. Contacts on the B-8 solenoid contactor close firmly at 6 volts, whereas on the B-4 type, 18 volts are required. The B-8 solenoid contactor with terminal bolts, nuts and washers, weighs approximately three-quarter pounds less than the B-4 unit. Being a single-



pole contactor with double-break normally open contacts, the new unit is so constructed that the contacts do not chatter as a result of voltage drops caused by starting motor current surges. Contacts are rated at 200 amperes, and the unit operates at 24 volts direct current, intermittent duty. At 24 volts the coil draws 3 amperes. Vibration resistance exceeds ten times gravity.

Tubing Connector Introduced

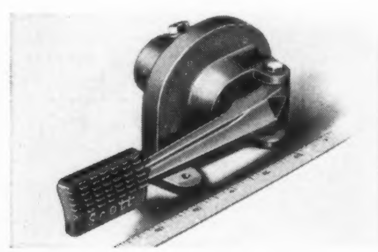
DESIGNED to meet the need for an improved type of tube fitting, Grinell Co. Inc., Superseal division, Providence, R. I., has announced its Superseal tubing connector, the design of which lends itself to being produced from any metal. This makes it adaptable to all types of tubing. Long 10-de-



gree tapered cone provides greater seating area for tubing flare, assuring a leakproof joint under maximum vibration and pressure. The inside diameter of the tubing is maintained, and assemblies can be disconnected and reconnected many times without injuring the fitting or tubing. Tubing bends can be made extremely close to the fitting. The fitting can be used with welded, brazed or seamless steel tubing, and all nonferrous tubing for use on oil, gas, air, chemical and other lines. It is made at present of steel in sizes up to and including ½-inch outside diameter and of malleable iron in sizes of ⅝-inch outside diameter and larger. The standard protective coating for these fittings at present is a wax finish.

Hydraulic Brake Pressure Unit

SIMPLE in design is the new hydraulic pressure unit developed by Scott Aviation Corp., Lancaster, N. Y. For use on light aircraft, it is primarily intended to be used with the expander type brake although it may be adapted to other types. Mounted on the floorboards, it is located so that the pedal is in conventional relationship to the rudder pedal. Lubrication of the unit is required only at two points, the pedal bearing and the plunger ball joint. Any standard brake fluids can be used. The flexing-diaphragm piston type of construction prevents loss of fluid due to the fact that it provides a completely sealed hydraulic pressure unit. Specifications include: Displacement .8-cubic inch; maximum working



pressure, 350 pounds; test pressure, 600 pounds; weight, 21 ounces. Operating temperature tests have been conducted satisfactorily at temperatures as low as −40 degrees Fahr. and as high as 125 degrees Fahr.

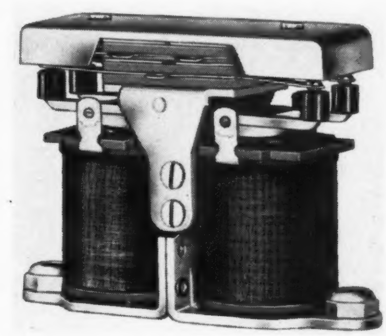
Free-Machining Alloy Offered

OF PARTICULAR interest to engineers is the development of a free-machining Invar—a new low thermal expansion alloy which can be machined as much as 72 per cent faster than the regular type. Produced by The Carpenter Steel Co., Reading, Pa., the 36-per cent nickel alloy known as Invar had long been limited by machining difficulties and these have now been overcome by the development of the free-machining grade. Invar in various forms has been used for some time where natural tendency of metals to expand when heated must be minimized. By providing a rate of thermal expansion approximately one-tenth that of carbon steel, at temperatures up to 400 degrees Fahr., this alloy is contributing to the accurate operation of radio and electronic

devices, aircraft controls, thermostats, etc. Addition of selenium to the alloy gives it free-cutting properties without altering the low thermal expansion characteristics. The name of the new alloy is Free-Cut Invar "36".

Double Armature Relay

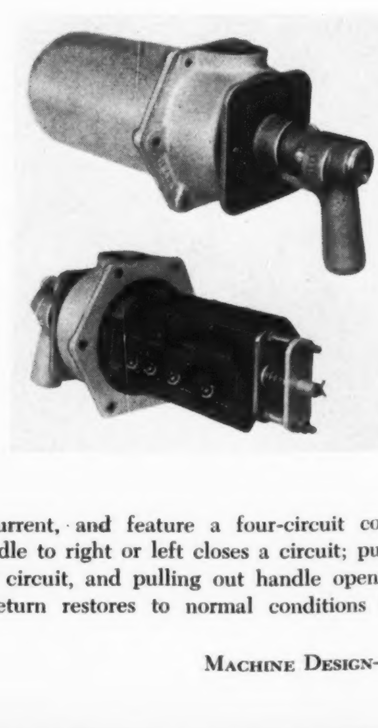
AVAILABLE in various contact arrangement or with microswitches in place of spring pile-ups, a balanced armature relay has been introduced by Cook Electric Co., Chicago. This relay—a double-action interlocking control unit with balanced armature control—can be "tailor made" to fit



into designs where its light weight and small size are an advantage. Built to withstand constant vibration and sudden shocks of mobile applications, the relay has capacities up to 5 amperes, 110 volts alternating current rating; coil capacity 10,000 ohms each; and contact forms or assemblies up to 12 springs on each side. Overall measurements are: 2¾ x 1 15/16 x ⅞ inches.

Switches Are Immersionproof

IMMERSIONPROOF control switches have been added by Delta-Star Electric Co., 2400 Block Fulton street, Chicago, to its line of Type "M" control switches. These new immersionproof switches are rated at 20 amperes or 600 volts al-



ternating current, and feature a four-circuit control. Turning the handle to right or left closes a circuit; pushing handle opens third circuit, and pulling out handle opens the fourth. A spring return restores to normal conditions by releasing

handle after operation. Locking device is incorporated in the handle if it is desired to keep the handle in any normal or pushed-in position. The switching mechanism is enclosed in a durable case.

"Nicro Steel" Casters Offered

DEVELOPED for portable tanks, pumps, dollies and floor trucks by Rapids-Standard Co. Inc., 535 Bond avenue, Northwest, Grand Rapids, Mich., the new casters of "Nicro Steel" castings embody large diameter ball raceways. Strength of this material permits a long lead or "rake". Metal or ABK resinoid wheels have roller bearings in most models, oilite or

porous iron bearings also being available for metal wheels. Sizes range from 3 to 6 inches in diameter. In both the swivel and wheel, pressure lubrication fittings are provided. According to the company, test models have performed satisfactorily under loads ranging from 400 to 800 pounds per caster in average industrial plants over wood, concrete or end-wood-block floors.

Plug-In Electrolytic Condensers

RECOMMENDED for the elimination of low frequency ripple (2 - 100 cycles), Sprague Specialties Co., North Adams, Mass., has improved its "plug-in" type dry electrolytic condensers. This condenser can be sealed as well as any condenser and can be easily mounted or removed. It is built to take abuse and can be entirely soldered or welded into units. Of small size and light weight the condenser performs uniformly and accurately and will take repeated surges even higher. Underloads likewise are not a problem. This electrolytic unit is designed to operate under adverse temperature and climatic conditions, whether at extremely high or at normal levels.

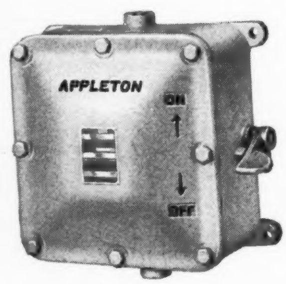
Adjustable Electronic Timer

MADE by Photovolt Corp., 95 Madison avenue, New York, a new electronic timer is designed for single actuation as well as for sequence timing and recycling in continuous operation. This adjustable timing relay with immediate automatic resetting for timing periods from 1/20-second and up

is applicable to numerous machines. Its construction is such that all parts are fastened to the top panel and the housing serves only as the cover. All that has to be done to build-in the timer as an integral part of a machine is to remove the housing. Dial divisions are arranged in approximately geometrical progression so that turning the knob by a given angle will result in the same percentage of increase or de-

crease of time interval. The timer is available in both alternating and direct-current models, with a load outlet carrying 110 volts and with terminals for opening or closing an external circuit. Powered and unpowered loads can be switched simultaneously. Adjustable for normally open and normally closed operation, the timer can be actuated by pushbutton, external switch such as a foot pedal or a machine-operated switch to be connected to the remote control socket of the timer.

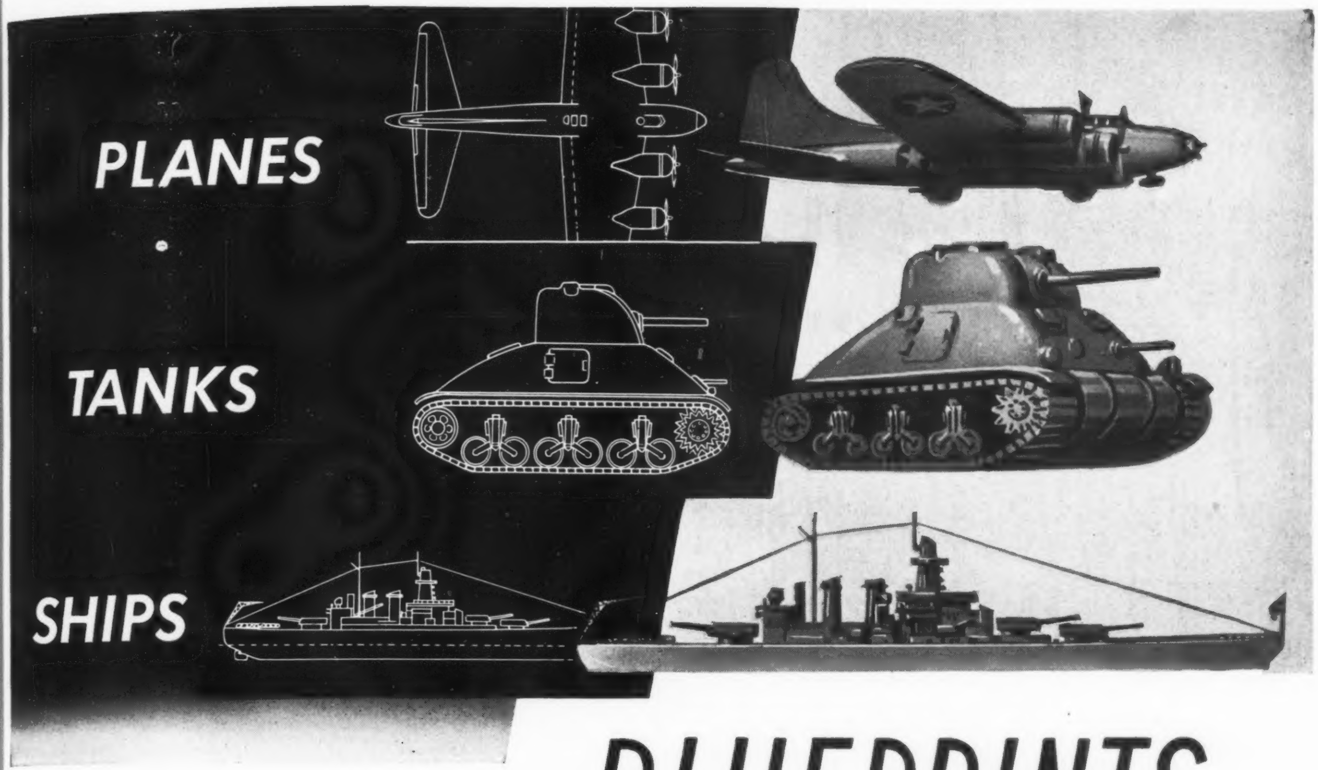
Explosionproof, Dust-Tight Switch



TYPE "FLS" explosionproof and dust-tight switch now being offered by Appleton Electric Co., 1701 Wellington avenue, Chicago, for general use and motor circuits, is primarily a safety unit built in a heavy malleable housing, manually operated, and made in accordance with the Underwriters' requirements. The switch is available in 30 and 60 amperes ratings, with 2 and 3-pole single-throw units for 250 and 600 volts service. The units have one hub in each end, threaded for conduit.

Aluminum-Coated Sheet

DEVELOPED by The American Rolling Mill Co., Middletown, O., Aluminized Steel, a new specialty sheet metal, is being used where exceptional resistance to heat and corrosion is needed. The aluminum-coated sheet, with a mild steel base, combines the surface advantages of aluminum with the strength of steel. The metal withstands temperatures up to 1000 degrees Fahr. without discoloration, and the aluminum coating will not peel or flake in moderate forming or drawing operations. Paint holds on Aluminized Steel, yet for most uses the unpainted surface is satisfactory. Although it has all the surface qualities of aluminum, a 16-page sheet of the coated steel uses only five per cent as much of the lighter metal as a solid aluminum sheet of the same thickness. At



BEGIN LIFE AS BLUEPRINTS

AT 30 FEET PER MINUTE ON PEASE MODEL "22" MACHINES

In placing our Vital War Equipment Designs on a mass production basis, Blueprints are indispensable. To provide the necessary Blueprints in volume and on time, Pease Blueprinting Machines are indispensable. They operate faster, more economically and require less attention... make sharper, clearer, more contrasty prints at 30 linear feet per minute... a performance unequalled by any other tracing reproduction equipment.

Get acquainted with the Pease line of Continuous Blueprinting Machines and you will understand why Government Departments, Commercial Blueprinters and industrial organizations rely on Pease Blueprinting Equipment to help speed production in our Victory program.

***Pease Special Features** that help speed production. **Sliding "Vacuum-like" Contact** smooths out tracings. **Three Speed Lamp Control** provides operation at 10, 15 or 20 amperes, does away with running speed and dryer heat changes. **Actinic "No-break" Arc Lamps** burn for 45 minutes without breaking arc, resume instantaneously. **Horizontal Water Wash** floats prints free from tension and prevents wrinkles, stains, bleeding. **Quick Change Chemical Applicator System** very economically allows change from Blueprints to Negatives in 30 seconds. **Rapid Drying Drums,** heated by gas or electricity, are thermostatically controlled.*

Pease Model "22" Continuous Blueprinting, Washing, Developing and Drying Machine. Production Speed 30 feet per minute.

THE C. F. PEASE COMPANY

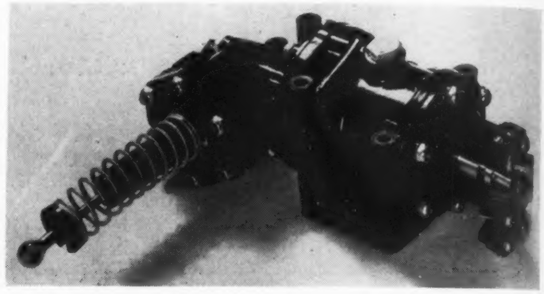
2606 WEST IRVING PARK ROAD • CHICAGO, ILLINOIS

Blueprinting Machines A TYPE AND SIZE FOR EVERY REQUIREMENT INCLUDING DIRECT PROCESS PRINTING

the present time the metal is used in aircraft for fire walls and air intake filters, and is being considered for cowling.

Controls Manifold Pressure

SIMPLIFYING the pilot's job, a new automatic boost control offered by Simmonds Aerocessories Inc., 21-10 Forty-ninth avenue, Long Island City, provides automatic manifold pressure control of engines in planes flying at various altitudes without the necessity of the pilot manually operating the carburetor controls. Most readily described as an automatic manifold pressure regulator or power control, it includes a small bellows or capsule of extreme sensitivity,



enclosed in a housing connected to the engine manifold, with a servo-piston and oil slide valve that connect to the engine oil systems. With the increase of manifold pressure the bellows contract, causing the slide valve to move and open oil ports which allow oil to flow to one side of the piston. This results in closing the throttle partly and in maintaining the predetermined manifold pressure. The boost control, known as Type 40, in addition to simplifying the pilot's job, prevents possible damage to the engine as a result of the development of excessive manifold pressure.

Glass for Electrical Insulation

IN ITS new line of electrical insulation The Corning Glass Works, Corning, N. Y., is introducing its Multiform insulators. The dielectric strength of the insulators is 500 volts per mil or more which is sufficient for ordinary applications. Among other advantages claimed are: Minimum frequency drift, negligible water absorption, and low loss factor. Multiform insulation parts include: Radio coil forms, coil form end plates and flanges, capacitor bushings, tube socket bases, rest bar insulators, antenna strain insulators, filament guides, rectifier rings, switch cups, co-axial line spacers, condenser spacers, mounting blocks, various beads and wafers, and many other electrical and industrial parts.

Positive-Type Vacuum Pump

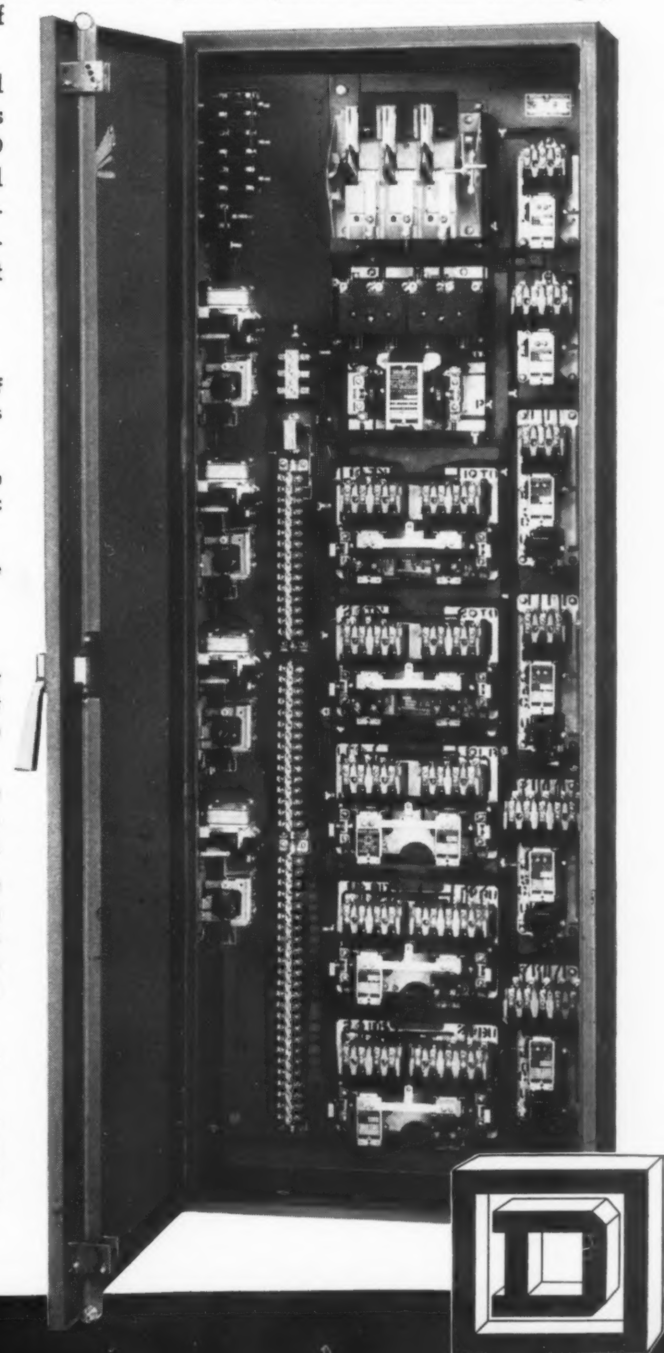
ANNOUNCED by American Automatic Typewriter Co., 614 North Carpenter street, Chicago, is a positive-type vacuum pump for production and laboratory applications. It is obtainable in two standard sizes with individual electric motor drives, or without motors for use with an available power source. The pump employs four bellows mounted within a square wooden frame, connected to each other and to the pump outlet by a channel running through the frame. These bellows are successively expanded to exhaust air or gas from the equipment to which the pump is con-

(*Continued on Page* 168)

PUT THROUGH ITS PACES
with SQUARE D CONTROL

This Complex Electrical Control Panel Is Assembled Entirely from Standard Square D Catalog Items

Both manual and automatic sequences are provided by this control panel, guided by signals from precision limit switches or a manual control station located on the machine. Square D pneumatic timers with large, calibrated adjusting dials, determine the amount of rivet flattening and head retraction.



Although it performs many specialized functions and governs the highly complex operation sequence, this panel is assembled entirely from standard Square D catalog items, designed specifically for machine tool control. Notice that the uniform construction and regular rectangular shape of each unit permits the assembling of a large number of devices and a great amount of wiring, in a relatively small space.

MANUAL OPERATION

1. From a master control station the operator governs motion of longitudinal feed rolls and transverse positioning of heads as well as initiating the riveting cycle.
2. Through selector switches on the control panel the operator can reverse the feed rolls, set the machine for manual or automatic operation and turn off either or both of the heads.
3. Either pair of heads can easily be backed off to one side while the other is operated manually or automatically.

AUTOMATIC OPERATION

1. A master gauge bar is attached to the work with stops set at riveting positions along the length of the work. Stops are set on a second master bar at riveting positions across the width of the work.
2. Work feeds lengthwise to first rivet position, where a precision limit switch, tripped by a stop on the master bar, stops feeds and energizes contactors on the control panel to start bucking heads down.
3. Sensitive limit switches stop bucking anvils at contact with the rivet heads and start riveting rams upward. As riveting anvils touch work, a pneumatic timing relay is energized and the rivet anvils continue to move upward, flattening the rivet heads until the timing period is over. Degree of flattening is easily controlled by a calibrated adjusting dial on the control panel.
4. After riveting operation is complete, bucking and riveting heads retract while the feed rolls move the work to a new position.
5. Independent circuits for each pair of heads are provided on the control panel to allow riveting at different levels. These circuits are designed to automatically compensate for changes in work thickness or riveting levels as the machine progresses from one riveting position to another.

DETROIT - MILWAUKEE - LOS ANGELES

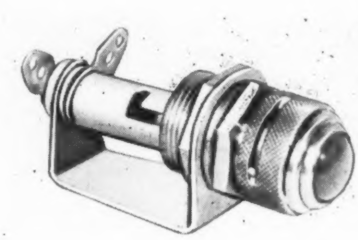
KOLLSMAN INSTRUMENT DIVISION, ELMHURST, NEW YORK • IN CANADA: SQUARE D COMPANY CANADA LIMITED, TORONTO, ONTARIO

(*Continued from Page 164*)

nected, and are driven by a revolving shaft through connecting straps. Shaft is V-belt driven at approximately 200 revolutions per minute, the relatively slow speed providing a smooth quiet-running unit. The flexible sides of the bellows are of leather as are the intake and exhaust valves. All joints are gasketed by a sheet of neoprene cloth. The frame or case has a black wrinkle finish. The larger of the two units is rated at 15 cubic feet displacement at 4 inches of mercury. Bellows are 6 inches wide, and pumps individually driven use a ½-horsepower motor. The smaller unit, rated at 7 cubic feet displacement at 4 inches of mercury, has 4-inch bellows and uses a 1/6-horsepower motor. Pumps are equipped with governors to vary the capacities.

Shutter-Type Pilot Lights

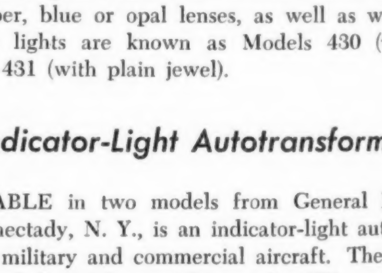
PARTICULARLY suited to aircraft, marine, signal and similar applications where various intensities of light are desired under changing conditions, The Gothard Mfg. Co., 1300 North Ninth street, Springfield, Ill., has brought out a new shutter type pilot light. These lights permit a graduation of



light from bright, through intermediate glows, to total darkness with 90-degree rotation of shutters. Available with red, green, amber, blue or opal lenses, as well as with polarized lenses, the lights are known as Models 430 (with faceted jewel) and 431 (with plain jewel).

Indicator-Light Autotransformers

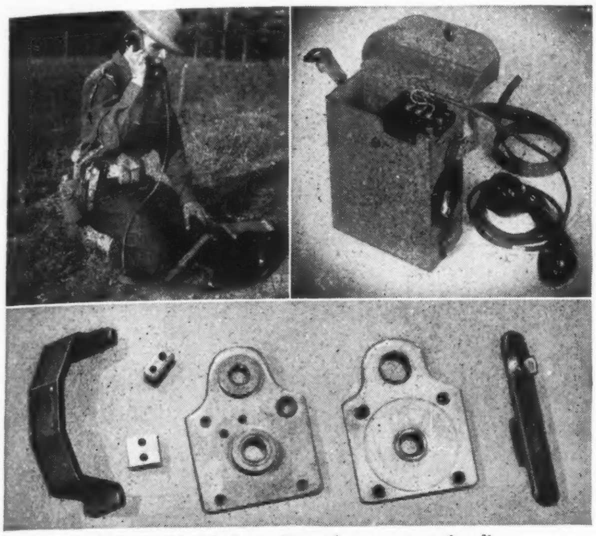
AVAILABLE in two models from General Electric Co., Schenectady, N. Y., is an indicator-light autotransformer for use on military and commercial aircraft. These autotransformers are lightweight, weighing only 13¼ ounces. Size is 2¼ x 3¼ x 1½ inches. Made to resist vibration and corrosion, they operate satisfactorily at altitudes from sea level to 60,000 feet and at ambient temperatures from −40 to 140 degrees



Fahr. A 30-va output at 3.01/1.5 volts is furnished by either the 115 volt or the 26-volt model, capable of operating fifty-two .19-ampere T-1 ¼ bomb-indicator lights. Both models operate from a 400-cycle, single-phase supply. For dimming the indicator lights a 1.5-volt tap is provided, making possible reduction of excessive brilliance in cockpit lighting when de-

FOR WAR TODAY—FOR YOUR PRODUCTS TOMORROW

PRE-WAR ENGINEERING SHOWED THE WAY



Die castings help to "get the message thru"

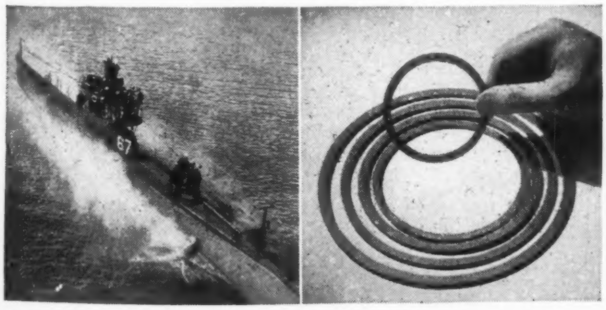
Unhampered by tradition, the designers of communications equipment have taken full advantage of all developments in materials and production methods. It is of particular significance, therefore, that zinc alloy die castings have found such wide use in the manufacture of communication and allied products.

The wartime counterpart of the communications industry—the U. S. Army Signal Corps—is profiting by pre-war advancements in telephone production. For example, the EE-8-A field telephone utilizes the six zinc alloy die castings shown at the bottom of the above illustration. These castings were adopted only after exhaustive testing in competition with parts produced by other methods and of other materials.

Post-war designers please note.

5 IN 1

Pictured below are five bezels for gauges on submarines. They are die cast of zinc alloy and, at first glance, you may ask why. The answer is elimination of scrap loss—a major problem in all metal production today. Actually, by die casting all five rings in a single die, they are produced at little more expense than would be involved in die casting the largest ring alone. The individual rings are broken off the gate and the small amount of metal which joined them is remelted and reused.



The small cored holes in the rings permit grip of a spanner wrench for assembly

THE New Jersey Zinc ALLOY POT

A publication issued for many years by The New Jersey Zinc Company to report on trends and accomplishments in the field of die castings. Title Reg. U. S. Pat. Off.

MACHINE DESIGN EDITION No. 7

Compare these savings with the scrap loss involved in the alternative method of stamping from sheet metal, and you can understand why the die casting process was selected.

BAKED FINISHES FOR ZINC ALLOY DIE CASTINGS

Almost any known type of finish can be applied on zinc alloy die castings. The wartime shortage of electro-plating materials has, however, focused attention principally on organic coatings, of which there are many types to meet specific service requirements of die castings. In the case of baked finishes on zinc alloy die castings, the relatively low melting point of the alloy should be kept in mind. Finishes on zinc alloy die castings should not be baked at temperatures higher, or for periods longer, than indicated in the table below.

The subject of finishing is fully covered in the bulletin "The Finishing of Zinc Alloy Die Castings and Rolled Zinc." A copy will be sent to you upon receipt of a request on your Company letterhead.

MAXIMUM TEMPERATURE —°F. FOR TOTAL BAKING TIME OF

Alloy	½ Hour	1 Hour	2 Hours	3 Hours
* Zamak 2†	325	275	250	250
Zamak 3††	425	375	325	300
Zamak 5†††	425	375	325	300

* Trade Mark Reg. in U. S. Patent Office
† Corresponds to A.S.T.M. Alloy XXI, S.A.E. No. 921
†† Corresponds to A.S.T.M. Alloy XXIII, S.A.E. No. 903
††† Corresponds to A.S.T.M. Alloy XXV, S.A.E. No. 925

THE NEW JERSEY ZINC COMPANY
160 FRONT ST., NEW YORK CITY

HORSE HEAD SPECIAL (99.99 + % Uniform Quality) ZINC

sirable, and preventing lamp failure due to overvoltage when only part of the lamps are lighted. The new autotransformers conform to U. S. Army Air Force specifications.

Engineering Dept. Equipment

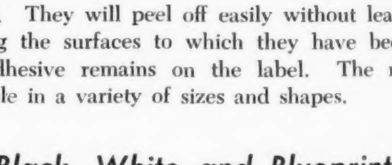
Stickers for Drawing Boards

ATTACHING drawings and blueprints to drawing boards with Kum-Kleen Stickers produced by Avery Adhesives, 451 East Third street, Los Angeles, Calif., eliminates the necessity of moving the T-square over thumb tack heads. Paper thin, the stickers will lie flat and are applied without

moistening. They will peel off easily without leaving a trace or affecting the surfaces to which they have been attached. All the adhesive remains on the label. The new stickers are available in a variety of sizes and shapes.

Black, White and Blueprinter

FOR making blueprints or black and whiteprints a new "Spee-Dee" printer has been developed by Peck and Harvey, 4325 Addison street, Chicago. The time required for making either blueprints or black and whiteprints is half-a-minute. Exposure time is frequently as little as 20 seconds. Developing time for black and whiteprints (Directo process) is only 10 seconds. The unit is a portable, table model and



can be plugged into any standard electric outlet. It is furnished in two sizes: For prints up to 12 x 18 inches and 18 x 24 inches. In the illustration is shown the 12 x 18-inch model with two 8½ x 11-inch prints inserted. Actual printing surface is oversize on both machines, preventing crowding of prints, overlapping or blurred edges. Tracings, drawings or any written or printed matter can be quickly and clearly printed on this machine.

MEN OF MACHINES

HAVING had wide experience as a development engineer, W. I. Gladfelter was recently made vice president in charge of operations at Crown Can Co., Philadelphia. Much of his early training was gained at the Sparrows Point, Md., plant of Bethlehem Steel Co., and later when associated with the Westinghouse Electric Mfg. Co., East Pittsburgh, he obtained a background in the development of electric locomotives. He then joined the Crown Cork and Seal Co. engineering staff at Baltimore. While here he was successful in designing the present modern type bottling machinery. Later he was development engineer for Crown's seamless can,

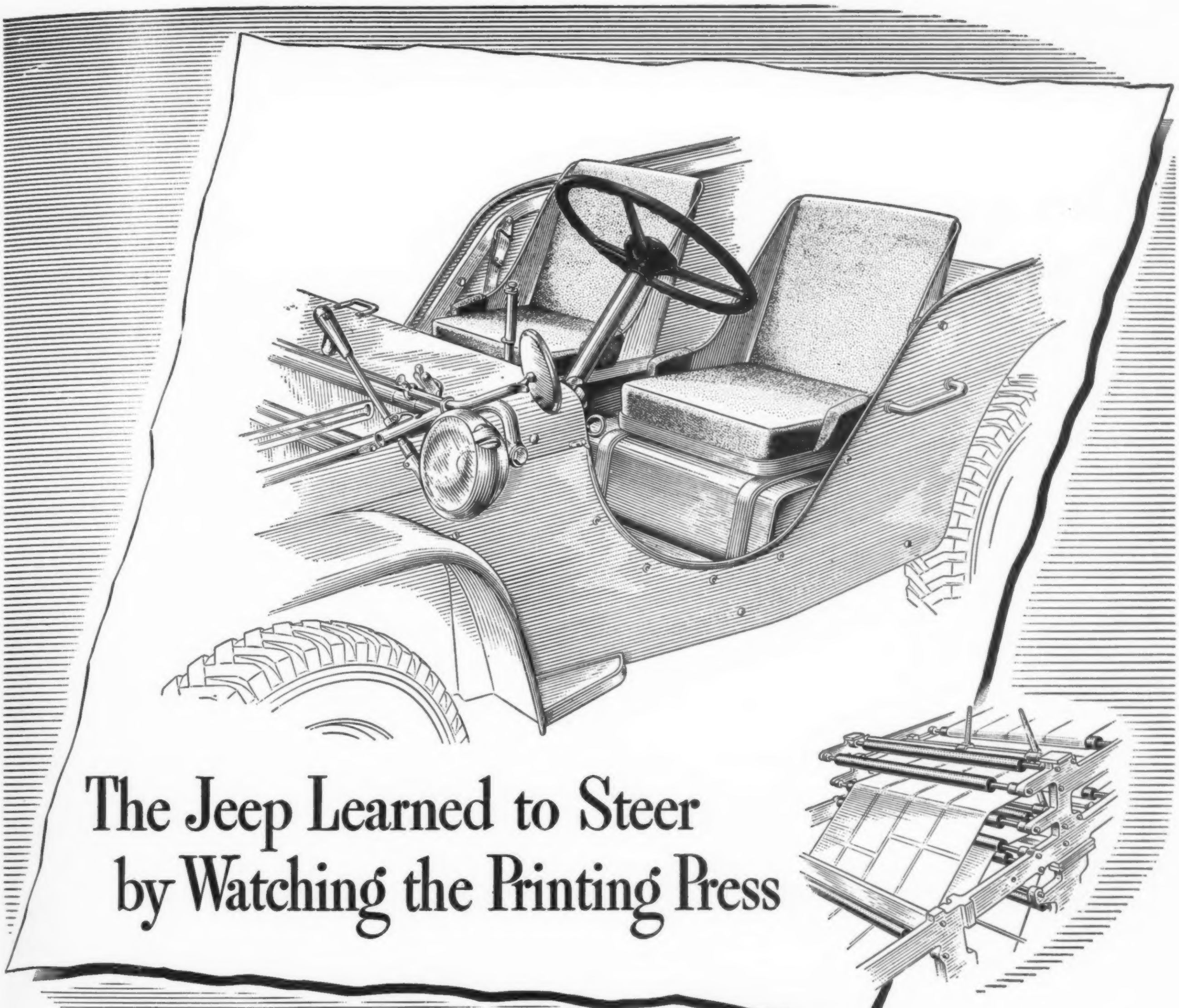
the manufacture of which involved many innovations in the container industry. In 1939 he was promoted to chief engineer of the Crown Can Co., and last year was made general manager of production and engineering. In his new position Mr. Gladfelter will have under his direction all of the company's engineering and production operations.

F. Brint Edwards, formerly general design engineer, has been made assistant project engineer, Vega Aircraft Corp., Lockheed Air Terminal, Burbank, Calif.

R. Bruce Wiseman, previously junior designer, Buda Co., is now an engineer with Waukesha Motor Co., Waukesha, Wis.

George H. Kendall has become connected with Sargent & Co., New Haven, Conn., as chief engineer. Formerly Mr. Kendall was associated with Norma-Hoffman Bearings Corp. as consulting mechanical engineer.

Leonard Troy is at present connected with the Strickland Aircraft Corp., Topeka, Kans., as vice president in charge of



The Jeep Learned to Steer by Watching the Printing Press

IT'S TOP-SPEED operation hour after hour in a printing press—no leeway for breakdowns that might delay the newspaper on its way to the waiting delivery trucks. So printing press makers picked the Torrington Needle Bearing for its ability to operate successfully in high-speed service, with little need of attention.

There's no question of high speeds in the steering column of a jeep, of course ...just an occasional turn through a fraction of a revolution. But that point of long life with little attention looked just as good to the jeep builders as it did to the press manufacturers. They, too, turned to the Needle Bearing, not only for its ability to stand up in severe service, but for its low friction coefficient that gives quick response to the steering wheel, its small size that contributes to compact design, its effective system of lubrication, its ready availability for all essential applications.

THERE'S A THOUGHT HERE FOR YOU TO CONSIDER when you start the design of your post-war products. Whether your problem is one of oscillation or of high-speed rotation, the Torrington Needle Bearing will give your customers the advantages of dependable operation, efficient lubrication, low starting and running friction. And of course, *you* will benefit by the Needle Bearing's low cost and ease of installation. You can get the preliminary information you will need by writing for Catalog No. 109, which lists sizes, rates, and typical applications—and Torrington engineers will assist you in working out specific service problems.

THE TORRINGTON COMPANY
Established 1866 • Torrington, Connecticut, U. S. A.
Makers of Needle and Ball Bearings
New York Boston Philadelphia Detroit
Cleveland Seattle Chicago San Francisco
Los Angeles Toronto London, England

TORRINGTON NEEDLE BEARINGS

KEYED TO TODAY'S NEEDS

AND TOMORROW'S TRENDS

engineering. He had previously been engineer in charge of weights and structures, Aeronautics division, Snead & Co.

Eliott Daland, design engineer, Platt Le Page Aircraft Co., has joined the P. V. Engineering Forum, Philadelphia, as chief engineer.

Murray Ireland, who began with the company as an engineer-designer in 1925, has been elected vice president of Toastmaster Products division, McGraw Electric Co., Elgin, Ill.

Charles G. Aitkin, previously vice president in charge of engineering for the H. K. Ferguson Co., has been elected president of the Osborn Engineering Co.

M. I. Alimansky has been named engineer in charge of the capacitor section of General Electric's Pittsfield Works.

W. H. Paul, formerly associate professor of mechanical engineering, has been made professor of automotive engineering, Oregon State college, Corvallis, Ore.

John C. McPherson has been appointed director of engineering, International Business Machines Corp., Endicott, N. Y.—this after two years as manager of the Future Demands department of the company.

W. H. Pearson has joined Kellett Autogiro Corp., Upper Darby Pa., in the capacity of engineer. He had been connected with Szekely Co. Inc. as chief engineer.

Wm. W. Dunnell Jr., formerly chief engineer of Reece Button Hole Machine Co., Boston, Mass., has been appointed to the staff of the Division of Industrial Cooperation of Massachusetts Institute of Technology.

John P. Vidican, contract engineer at Spalek Engine Co., Detroit is now project engineer with Vultee Aircraft Inc., Allentown, Pa.

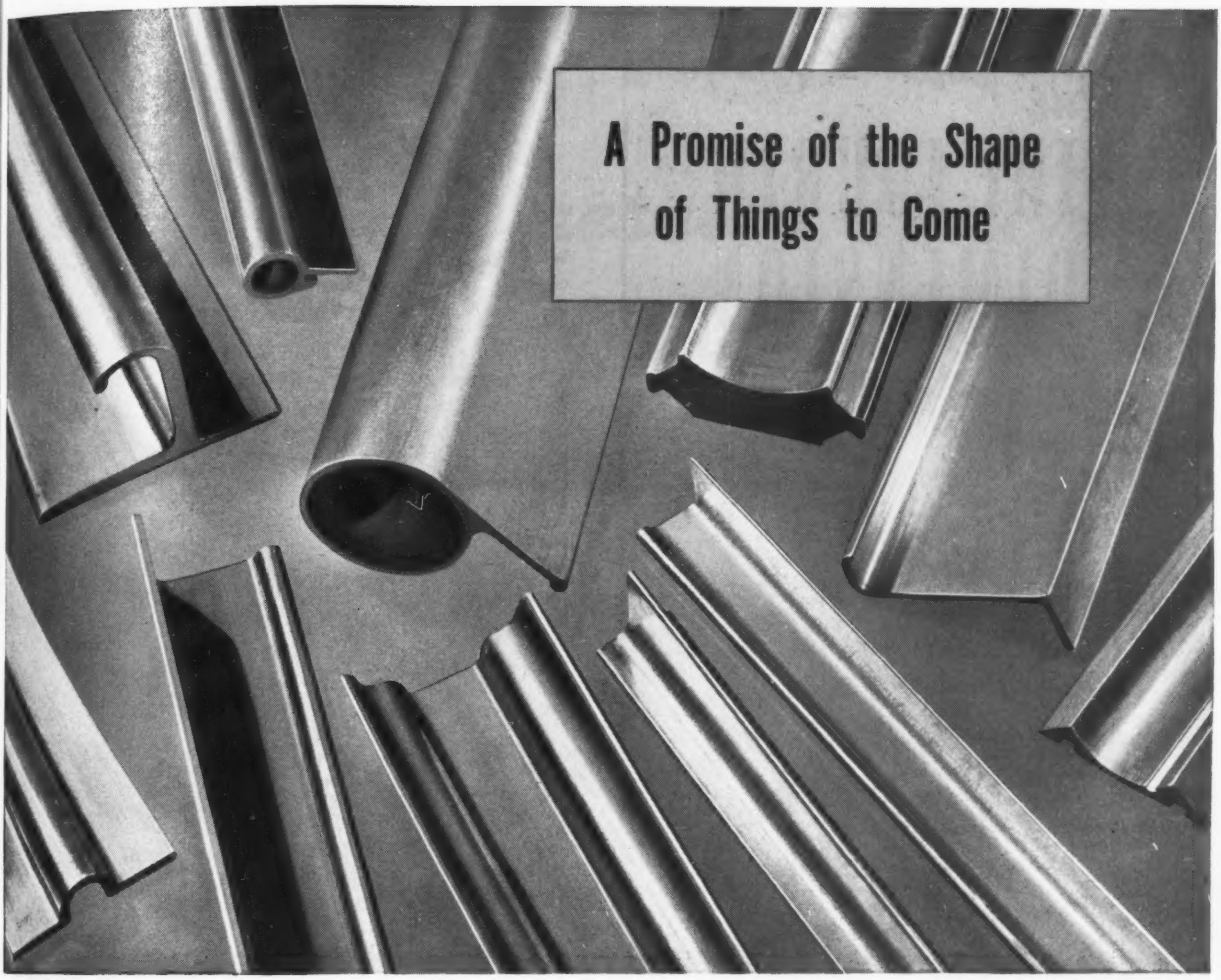
Wilfred Sykes has received the honorary degree of doctor of engineering from the Illinois Institute of Technology at its 1943 commencement. Mr. Sykes is president of Inland Steel Co.

L. G. Bean who has been vice president and general sales manager since 1939 of the Bristol Co., Waterbury, Conn., has been appointed vice president in charge of engineering and sales. Mr. Bean is a graduate of Worcester Polytechnic institute.

Dr. Alphonse Pechukas, with the company since 1937 and since 1942 serving as acting director, has been appointed research director of the Columbia Chemical division of Pittsburgh Plate Glass Co. Dr. Franklin Strain has been made assistant research director.

Harold E. Talbott has resigned as director of the aircraft production division of the War Production Board.

Dr. Joseph Slepian, associate director of research, Westinghouse Electric & Mfg. Co., East Pittsburgh, has been



They're weight savers, these Mazlo Magnesium extrusions. Such shapes supply strength and stiffness to fighting equipment, while holding weight to a minimum. They're an indication of the ways designers of postwar products will be eliminating excess weight.

The extrusion process has the advantage that it places metal exactly where needed. A heavy section here, less metal there; each piece does the mechanical job demanded of it. And, usually, very little machining is needed to get it ready to go to work.

For over twenty years, American Magnesium Corporation engineers have been helping manufacturers use magnesium extruded shapes to best advantage. Many a war plane is a better fighter today because this experience was available to its designer. You'll have that experience to turn to when you again take up peacetime production... Sales Agent for Mazlo Magnesium Products: Aluminum Company of America, 1703 Gulf Building, Pittsburgh, Pa.

MAGNESIUM MAZLO PRODUCTS

REG. U.S. PAT. OFF.

AMERICAN MAGNESIUM CORPORATION

SUBSIDIARY OF ALUMINUM COMPANY OF AMERICA

awarded the 1942 Lamme Medal of the American Institute of Electrical Engineers "for his contributions to the development of circuit interrupting and current rectifying apparatus." The medal will be presented to him at the national annual meeting in June.

ANDREY A. POTTER, dean of engineering, Purdue university, and chairman of the National Advisory Committee on Engineering and War Training, has been named recipient of the Washington award for 1943 "for distinguished leadership in engineering education and research, and patriotic service in mobilizing technical knowledge for victory in war and peace."

M. E. FIRST, formerly chief engineer, has been named director of the foundry equipment department, C. O. Bartlett & Snow Co., Cleveland.

C. H. MATHEWSON, professor of metallurgy, Yale university, has been appointed president of the American Institute of Mining and Metallurgical Engineers.

JACK SANDLER has joined Aircraft Parts Development Corp., Summit, N. J., as chief plastics engineer. His former activity in plastics engineering was with the Northern Industrial Chemical Co. and the Nixon Nitration Works.

IGOR SIKORSKY has been elected an honorary fellow of the Institute of the Aeronautical Sciences Inc., and has been chosen to receive its annual Sylvanus Albert Reed award for 1942. Mr. Sikorsky, well known aircraft designer, is engineering manager of the Vought-Sikorsky Aircraft division of United Aircraft.

ARTHUR C. BRAUERIS is now working as project engineer on machine guns at the United States Naval Ordnance plant, Center Line, Mich. He formerly was assistant chief draftsman, Hudson Motor Car Co., Detroit.

DR. G. M. BUTLER was recently made chief metallurgist in charge of technical control and research of the Dunkirk laboratories of Allegheny Ludlum Steel Corp. He formerly was research engineer on internal combustion engine valve steels for the company.

LEO M. EDWARDS is now associate marine engineer, Navy Department, Brooklyn Navy yard, New York. He was previously chief engineering aide, Machinery Allowance section, Navy Department.

H. E. SIMI, SAE past vice president, has left Twin Coach Co. and is now a member of the C. L. Gougler Machine Co., Kent, O. He is in charge of the engineering of the company's latest plant, formery the Mason Tire & Rubber Co.

WILLIAM A. CRESSWELL JR. has accepted a position as analytical engineer of Ranger Aircraft Engines division of Fairchild Airplane & Engine Corp. as analytical engineer. He had been associate automotive engineer, United States Army Signal Corps, Radar Laboratory, Belmar, N. J.

WILLIAM B. STOUT has joined the research staff of the Consolidated Aircraft Corp. Although Mr. Stout will maintain headquarters in Dearborn, Mich., which will become the Stout

Research division of Consolidated, he is expected to spend time in San Diego, working with Harry Woodhead, president of Consolidated and I. M. Laddon, executive vice president.

John M. Frank has been elected president of the National Association of Fan Manufacturers. He is president of Ilg Electric Ventilating Co., Chicago.

H. W. Hem, formerly chief engineer, Toledo Scale Co., Toledo, O. has joined Howe Scale Co., Rutland, Vt., as research director.

James L. Rogers Jr., president of Plaskon Co. Inc., was recently made president of The Plastics Materials Manufacturers' association.

Paul Dyer Merica, vice president, International Nickel Co., and Essington Lewis, director general of aircraft production and munitions for the Commonwealth of Australia, have been elected to honorary membership in the American Institute of Mining and Metallurgical Engineers.

Dan R. Rankin who has been associated with the company for the past five years has been appointed acting chief engineer, Peerless Pump division, Food Machinery Corp., Los Angeles. He formerly was assistant to the chief engineer.

Nevin E. Funk, vice president in charge of engineering of Philadelphia Electric Co., Philadelphia, has recently been nominated as president of American Institute of Electrical Engineers.

Glenn L. Martin, president, Glenn L. Martin Co., Baltimore, has been made president of the Aircraft War Production Council Inc. J. Carlton Ward Jr., president, Fairchild Airplane & Engine Corp., was elected vice president, and Harold E. MacDonald, executive assistant to the director of engineering, Curtiss-Wright Airplane division, was made chairman of the advisory committee on engineering and standards.

Robert A. Weaver received an honary degree of doctor of science from Alfred university, Alfred, N. Y., in recognition of his work as a leader in the porcelain-enamel-on-metal branch of the ceramic industry. Mr. Weaver is president of the Ferro Enamel Corp., Cleveland.

Robert D. Williams and John A. Finley have been named research engineers on the technical staff of Battelle Memorial institute. Mr. Williams will assist in welding research, and Mr. Finley in research in metallurgy.

Ralph Miller has been appointed chief engineer of the Engine Research and Design division of Worthington Pump & Machinery Corp., Buffalo, N. Y. He was previously connected with the Diesel Engine division of American Locomotive Co., and prior to that was consulting engineer at Superior Engine Co., and chief engineer of the Diesel Engine department of Ingersoll Rand Co.

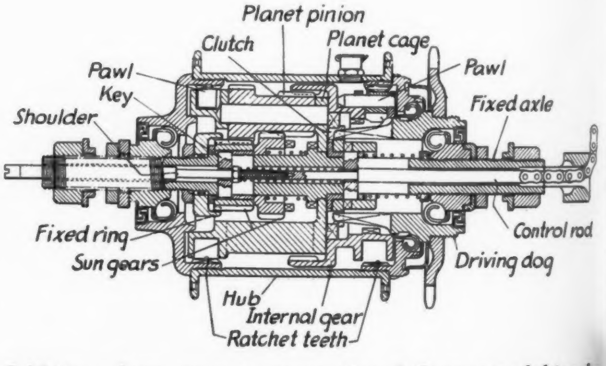
Correction: Harry Hall has been appointed assistant chief engineer of the Engine division, Worthington Pump & Machinery Corp., Buffalo, N. Y. instead of chief engineer as erroneously stated in the February issue of Machine Design.

Noteworthy Patents

Hub Transmission Provides Multiple Speeds

SELECTIVE speed transmissions of the hub type, such as are used on bicycles, provide an exceedingly compact drive but have hitherto been limited to three speed changes. Recent improvements now make possible additional speed ratios without sacrifice of compactness or radical changes from the conventional design, and are covered by patent 2,301,852, assigned to Sturmey-Archer Gears Ltd. While this type of transmission has been developed primarily for bicycles, in which the driving sprocket and hub rotate about a fixed axle, it is of course not limited to such applications and may be readily adapted to drives where the casing is fixed and the axle rotates.

A transmission providing four speed changes is shown in the illustration. Supported on a bearing at the right-hand end of the fixed axle is the driving dog carrying the chain sprocket. The two ends of the hub are journaled, respectively,

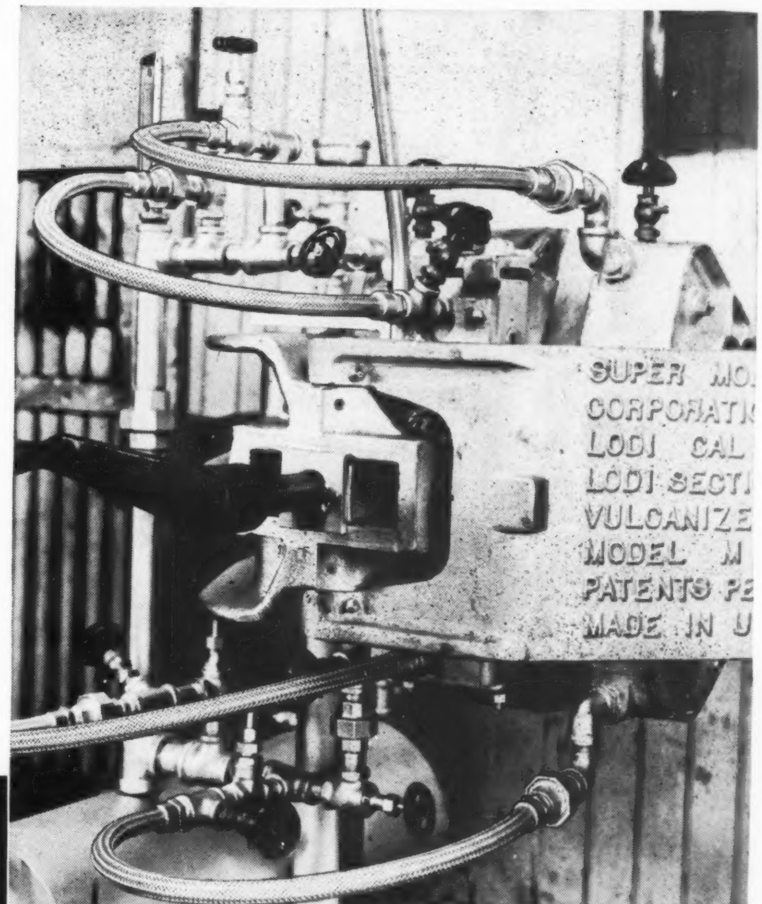


Addition of sun gear to conventional three-speed bicycle transmission increases number of selective speeds

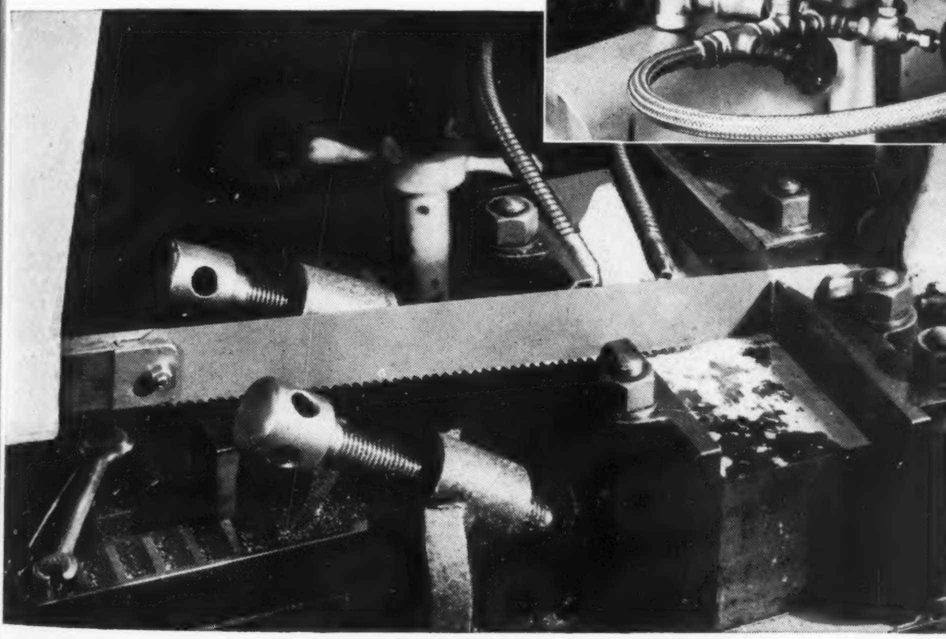
on the axle and on the driving dog. The planetary gear train inside the hub comprises an internal gear, compound planet pinions, planet cage, and two sun gears, either one of which may be fixed to provide the reaction element in the train. In operation with the gears in the position shown the smaller sun gear is fixed because the ends of the teeth engage internal dogs on a stationary ring. The planet cage is driven by the sprocket through the driving dog and a clutch, teeth on the latter engaging dogs on the planet carrier. Driven element is the internal gear which is connected to the hub through the right-hand pawl and ratchet. With this particular arrangement the planetary train functions as a speed-up gear, thus the hub rotates faster than the planet cage and the left-hand ratchet teeth override the pawl on the planet cage.

Partial movement of the control rod to the right brings the clutch out of engagement with the dogs on the planet cage and into engagement with a segment of teeth in the internal gear member. In this position the drive is transmitted from the driving dog through the clutch to the internal gear which again drives the hub through the right-hand

STANDS OUT BECAUSE IT STANDS UP



"RETREADING WAR-NEEDED TIRES" ➧
American Seamless Flexible Metal Tubing is ideal for steam lines on the modern tire-retreading machine, as witness this vulcanizer made by Super Mold Corporation. Fully flexible so as to allow free movement of the vulcanizer head, American Seamless is, of course, all metal . . . cannot dry out or crack under the intense heat required for vulcanizing.



"SAWING WAR-NEEDED METALS." A Simonds Saw and Steel Co. installation showing coolant lines of American Flexible Oil Feed and Coolant Tubing. Made of spring steel wire, this superior tubing readily bends to any position . . . stays put when bent . . . directs a continuous flow exactly where needed.

Whether you need a flexible connector for conveying air, water, oil, steam or fuel—for isolating vibration or for connecting misaligned or movable parts—the chances are we have a type of flexible metal hose or tubing that will do the job more capably.

Using virtually any workable metal, we can build flexible hose or tubing for applications ranging from a simple spout to a high pressure seamless hydraulic line that can be flexed millions of times without breaking. *American Seamless* gives you the flexibility of garden hose . . . the dependability of metal . . . *and the strength of rigid pipe.*

43198

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Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., *New Toronto, Ontario*

ANACONDA

American Metal Hose

pawl and ratchet, this being direct drive. Left-hand ratchet teeth override the pawls as before.

Further movement of the control rod to the right causes the clutch to trip the right-hand pawls out of engagement with the ratchet teeth, the pawls being hinged as shown. The smaller sun gear is still fixed and the planetary train therefore functions with the internal gear driving and the planet cage driven, giving a speed reduction. Because the right-hand pawls have been tripped out, the final drive is through the left-hand ratchet, the hub rotating with the planet cage.

Sliding Sun Gears Permit Extra Speeds

Next speed step is obtained by further movement of the control rod. By this time the clutch has reached the limit of its travel but the shoulder on the control rod to the left of the sun gears has made contact with the key inside the smaller gear. Further movement of the control rod therefore compresses the inside spring, allowing both sun gears to slide to the right until dogs on the larger gear engage corresponding stationary dogs on the axle and the smaller gear is free of the fixed ring. The planetary train functions with the internal gear driving, the larger sun gear fixed, and the planetary cage driven, the speed reduction being larger than in the previous step because of the difference in size of the sun gears. Planet cage drives the hub through the left-hand pawl and ratchet as before.

By dividing the control rod so that movements of the clutch and of the sun gears are independent of each other an additional speed-up drive may be obtained, using the larger sun gear as the fixed element while the driving dog actuates the planet cage and the internal gear drives the hub, as in the illustration. Additional speeds also are obtainable by providing additional sliding sun gears with a corresponding number of steps in the compound planet pinion. Total number of speeds, including direct drive, is always one plus twice the number of sun wheels.

Torsion Dynamometer Uses Vernier Scales

HORSEPOWER transmitted through a rotating shaft is conveniently determined from simultaneous readings of speed and of the twist in a calibrated length of shaft. The measurement of twist of the rotating shaft, however, presents certain obvious difficulties, one means of overcoming which is the subject of patent 2,302,496, recently assigned to Farrel-Birmingham Co. Inc.

As shown in the cut, page 184, driving and driven shafts are connected through a torsion shaft of reduced diameter and sufficient length to twist appreciably when transmitting the driving torque. Surrounding the torsion shaft and connected to the driving shaft but not to the driven is a sleeve provided at its free end with a scale disk adjacent to another scale disk attached to the driven shaft. Because the sleeve transmits no torque it is free from twist and the relative displacement of the two disks is the twist in the torsion shaft.

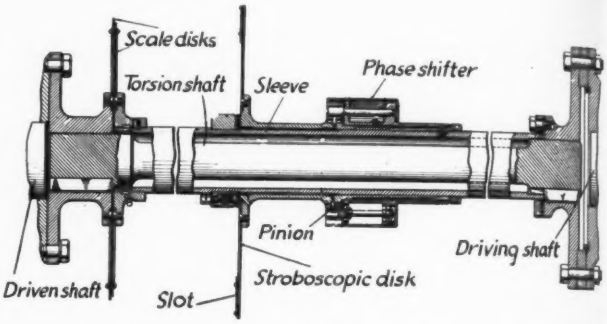
Peripheral evenly divided scales are attached to the disks, that on the smaller disk having one subdivision more than that on the larger, thus providing a vernier scale for accurate reading. Inasmuch as the scales rotate with the shaft a stroboscopic device is necessary to make them visible for reading. A flashing light synchronized with the rotation of the scales may be used, or a stroboscopic disk rotating with the sleeve, as shown in the illustration, may be preferred. At one point in the periphery of the stroboscopic disk a radial slit is provided, at the same radius as the graduations on

(*Concluded on Page* 186)

(*Concluded from Page* 182)

the scale disks. When viewed through the slit the scales appear to be stationary and the shaft deflection can therefore be read.

Because the subdivision lines of the two scales coincide at only one point on the periphery it is necessary to have means for varying the phase of the stroboscopic disk until the coincident point is brought into view. This is accomplished by mounting the disk on a sleeve which can be conveniently rotated with respect to the shaft while running. For this purpose a phase shifter is provided. The shifter supports



Vernier scales attached to driven shaft and to sleeve connected with driving end deflect as torsion shaft twists under load, reading being viewed through slit in stroboscopic disk

a pinion meshing with gear teeth cut in the abutting ends of two sleeves, one carrying the stroboscopic disk and the other attached to the shaft. Means are provided for braking the phase shifter, causing it to rotate at a slower rate than the shaft and resulting in rotation of the pinion. Because the gear connected to the stroboscopic disk has fewer teeth than the gear connected to the shaft, relative rotation of the two occurs and the phase of the stroboscopic disk is shifted. The movement being under control of the operator, the peripheries of the scales can be completely scanned and a reading obtained simply and expeditiously.

Aluminum Alloys Classified

CODE system for classifying and designating aluminum and aluminum alloys covered by A.S.T.M. specifications has recently been adopted by the society. Letters designate major alloying elements as follows:

A—Aluminum	N—Nickel
B—Copper	R—Chromium
G—Magnesium	S—Silicon
M—Manganese	Z—Zinc

Numbers also are used to define further the number of alloying elements present. Numbers below 20 indicate that only elements shown by code letters are present; between 20 and 40 there is one additional element other than those shown by letters; between 40 and 60 two elements other than those indicated; between 60 and 80, three additional elements; between 80 and 100, four elements, and so on.

For example, C2 is a copper-aluminum material, CS22 is a copper-silicon-aluminum alloy with one additional element, and ZG41 is a zinc-magnesium-aluminum alloy with two other elements also present.

LOAD LIMIT SWITCHES

Maintain War-production Schedules

ACROSS-THE-LINE Starters in single and double-pole, for small single-phase motors. Their *small size* fits in with compact designs of production machines and machine tools, whether surface-mounted or integrally located. Enclosure measures but 4 1/16" long; 2 11/16" wide; 2 1/4" deep.

Switch-action in this small compass is smooth, even, securely *positive.* Fine silver-to-silver contacts are of dependable butt type, with constant spring pressure. Mechanism is enclosed in dust-tight plastic base.

Wide range of overload protection derives from *21 sizes* of interchangeable heaters. These are easily attached or changed from the front without removing switch from housing or disconnecting wires. *One* heater is used for both single and double-pole jobs.

Standard enclosure for surface mounting is NEMA Type 1 general purpose steel box; machine gray finish. For specification-data on Starters, rating-tables for Heaters, write for new Catalog 9-M. Particularly address our Free Engineering Service on questions of *special adaptations* to unusual control problems.

INDUSTRIAL CONTROL DIVISION

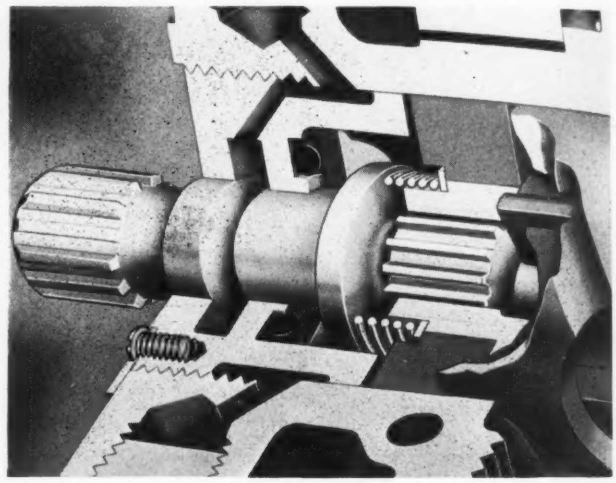
THE ARROW-HART & HEGEMAN ELECTRIC COMPANY, HARTFORD, CONN., U. S. A.

Wartime Drives and Controls

(*Continued from Page* 118)

dry. Design employed in a wet driveshaft provides an increase in ability of the shaft to take misalignment because it is cushioned indirectly on the seal against a synthetic rubber ring. The dry driveshaft employs a dry coupling which, in most instances, will allow misalignment between the accessory drive in the engine and the fuel pump shaft itself to a degree dictated by the particular design.

The shaft for the vane type fuel pump illustrated has been developed from a dry type with a spring-loaded seal to the wet type which employs a positive or pressure-



loaded seal. This shaft has an average service life of 3000 hours in contrast with the dry shaft using an Oldham coupling which had about half this service life. Spline drive engaging with the engine gives the same improvement over the square drive.

The dry shaft formed one member of an Oldham coupling used to obtain the universal joint action necessary for self-alignment. The fuel seal for this shaft was located ahead of the coupling so that there was no gasoline lubrication for the coupling. This, together with the fact that a coupling of this type takes the driving force on only two edges of the tongue and slot, makes this shaft design less satisfactory than the wet shaft.

External spline on the one end of the wet driveshaft engages with the internal spline of the pump rotor. Driving force is thus transmitted by the eleven-tooth spline in place of the two-point contact. Use of a synthetic rubber seal ring to cushion the stationary member of the seal gives more flexibility to the present design than the spring-loaded seal had. The new design needs no additional lubrication during service life while the old design required the addition of lubrication frequently. The gasoline being pumped provides all the necessary lubrication.

Certain problems are introduced by the use of a synthetic rubber ring to add to the flexibility of the drive. These, which in a large measure have been overcome, are:

1. Resistance to deterioration from immersion in aviation grade gasoline
2. Reduction of "cold flow" or permanent set to a negligible value
3. Ability to maintain original (room temperature) durometer hardness value in a temperature range of from minus 75 to plus 150 degrees Fahr.

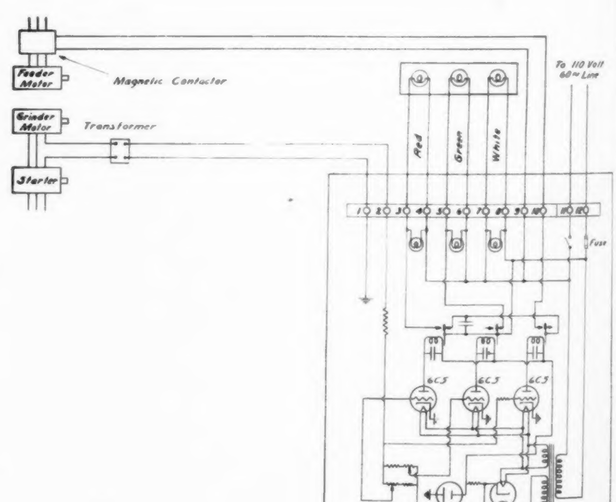
There are many outstanding advantages of the wet splined shaft over the dry shaft by reason of greater flexibility, longer life, and less maintenance time. Although there have been many minor variations in shaft design, the types described appear to be the two most general classifications.

Control Assures Maximum Production

By Max Mosher
Mosher Automatic Control Systems

IN GRINDING or pulverizing various materials, the load upon the grinder motor depends upon many factors beyond the control of the operator. For example, the grindability of the material under process may vary with the humidity. Arrangements for automatic control of the feed to the grinder, so as to decrease the flow of material to the grinder when the motor is overloaded, are well known. Through the application of electronics to this problem it has been found possible to simplify considerably the apparatus required as well as to increase its versatility.

From the accompanying circuit diagram the general principles of this type of control can readily be followed. A current transformer is placed in series with one of the



grinder motor leads. Across the secondary of this transformer a voltage appears, proportional to the load currents of the grinder motor. This secondary voltage is balanced by means of a voltage developed within the instrument. The balanced voltage may be varied over a sufficiently wide range to permit adjustments for operation from approximately 50 per cent to 125 per cent full load. The three electron tubes within the instrument are controlled by the differences between the balance voltage and the

original control voltage developed across the secondary of the current transformer. Through a proper adjustment of the bias voltages on the grid surface of the tubes, the operating points of the individual relays associated with each of the three tubes are set for operation at certain definite values.

When the grinder-motor load current increases beyond the point at which the control is set, the overload relay operates, flashing a red light and opening the circuit to the feeder motor. As soon as the grinder-motor load current drops to normal, this relay releases and the feeder motor restarts. A second relay is provided to indicate when the grinder-motor load current is 25 per cent below normal value. The third relay provides an interlocking safety arrangement which prevents operation of the feeder motor unless the grinder motor is in operation.

Because of the amplification from the electron tubes, compact relays of simple construction are used. The relay contact capacity of two amperes is sufficient to operate the feeder motor through a magnetically operated starting switch.

Floating Head Utilizes integral Drive

By Rupert S. Arnold
Bakewell Manufacturing Co.

TO SOLVE the problems of tapping heavy and bulky pieces of work accurately with an output to meet current war production demands, requires not only a machine with large working surfaces but also one with a floating head which would allow the tap to seek the center of the drilled hole, instead of bringing the work to the tap.

The tapping head of the radial drill illustrated is integral with a half-horsepower, two-speed motor, and is mounted on a radial arm which in turn is mounted on a hydraulically operated ram. The head moves quickly and easily on free-floating bearing hinge joints in the direction needed for the work, whether it is bolted on the horizontal base table or on one of the two vertical tables located on the left and rear of the base of the machine.

Using a special drive motor of high reversing action made it necessary to protect the tapping head against any jerking that might be caused by sudden starting or reversing of the motor. An automatic brake was therefore designed and placed on the intermediate arm between the head and the hoist column. In this way, the operator may swing the head into the desired position, center the tap, and press the starter button located in the handle of the head. At the half-way point, the starter switch automatically sets the brake. Completing the pressing of the switch, the motor is started with the brake set. The brake may be held at the option of the operator by holding in the starter button, or it may be released by releasing the button.

Accuracy in tapping is gained in a number of ways, the principal one being through the lead screw and guide-finger control. Essentially this consists of a hardened and ground lead screw which operates in conjunction with threaded brass guide fingers taking the place of the usual solid nut. The brass rods are brought into engagement against the lead screw by a solenoid located in a housing directly

behind the guide fingers. This lead screw has a hobbed upper section, and the matching threads are cut into the brass guide fingers. A perfectly mated fit is maintained between the guide fingers and the lead screw during the tapping operation. The plunger type solenoid with its toggle linkage brings the guide fingers into engagement with the lead screw with a spring-loaded pressure that absorbs any wear that may develop from long runs and that eliminates any backlash.

An electrically operated limit swich controls the depth and height limit of the tap stroke to within one-tenth of a tap revolution. A special index stop and plate are also provided which permit the operator to tap holes in different height levels of the work without resetting depth limits.

Another precision feature is the sensitive yieldable clutch which can be adjusted to the safe torsional resistance of the tap and the type of material being tapped. If the drive torque increases due to the tap becoming dull or from chips in the hole, the clutch will release and the tap will be saved from breakage.

Wartime Metallurgy

(*Continued from Page* 131)

tance of having this fiber run in the proper direction. There is no denying the fact that it is in some applications a dominant feature, *Fig.* 74. Obviously, however, its importance depends upon the *amount* of segregation and inclusions present, and upon the stress condition. It would seem to the writers that, with this in mind, the rather expensive practice has been too widely required.

A familiar example where grain flow is generally emphasized is in "upset forging" of pinion gears to the end that the fiber will run out into the teeth, parallel to the tooth axis. However, if the failure determinant is the bending stress at the root of the tooth, this analysis would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Dozens of Other Thy-mo-trol Extras . . . such as: low maintenance (by elimination of moving parts); speed can be preset before starting; saves space; no stop for speed change; easy to control automatically; operates direct from a-c line—no motor-generator or other special d-c supply needed.
Where Has It Been Applied? Drill presses, to increase speed range and size of work handled. Grinders, for precise speed selection and improved finish. Milling machines, to increase range of work handled, and to simplify design. Propeller testing, for accurate, smooth speed control. Cable reelers, to maintain constant tension. Conveyors, to match speeds.
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ignore completely the stress condition which is complex at the tooth fillet and can bear but little relation to this fiber direction. The *principal stress* directions (12, Part I) will be at an angle, being in fact parallel to the boundary at the boundry (13), *Fig.* 75. So far as the stress itself at this point is concerned it would seem that little is to be gained by such orientation of the fiber.

Where the determinant of failure is the contact stress (wear) of the gear tooth, however, there may perhaps be some importance in the fiber direction. Here the maximum *principal stresses* will be parallel to the tooth surface (14) at or near the pitch line and therefore approximately parallel to the tooth axis. Even here, when it is considered that failure is actually due to subsurface shear stresses which will be at 45 degrees to the tooth axis, rather than to the compressive stress, it is difficult to understand why the fiber direction should matter. It would seem that this subject is due for a review and further research, using the high-quality steels of today. Steels available at the time this opinion of fiber was formed contained far larger and more pronounced inclusions than today's steels.

It should be noted that the fiber of cold-worked steels is due to the elongation of grain structure more than to the impurities. As such its effectiveness is pronounced, a cold-rolled strip for example having highly directional physical qualities. *Fig.* 76 is a longitudinal view and *Fig.* 77 a transverse section of a lightly cold-rolled steel. *Fig.* 15 of Part II* illustrates the pronounced structure obtained by heavier working.

Defects in Steel

Discontinuities: Since steel contracts on solidifying, a shrinkage cavity or "pipe" of greater or less extent is generally left in the center. Proper practice in quality steel is to discard the upper portion of the ingot containing this pipe. However, in times of forced production in particular, this may creep into the steel. Inasmuch as the surface of the cavity will usually be oxidized it will not "weld up" in later mechanical working, but will persist into the finished steel and, if unfortunately located, may result in failure, *Fig.* 78.

A great deal has been done in recent years to eliminate pipe and other similar defects from quality steels by special mold designs. Practices include special, fluted walls to reduce surface cracks and checks; big-end-up ingots to induce freezing from the bottom up, reducing the length of the pipe; and refractory "hot tops", insulating extensions of the mold to maintain a pool of molten metal to feed the pipe, sink head cavity, and blowholes.

Blowholes are usually present due to gases liberated in solidifying. In good quality steel, thoroughly deoxidized, these should be few, small, and well distributed. They should have been formed by reducing gases such as CO or hydrogen, so that they weld shut with the usual amount of hot working, causing no trouble in later use of the steel.

Surface Decarburization: Decarburization occurs primarily in reheating of billets or bars and in hot-rolling operations. It can be expected on all hot-rolled stock. Since cold-drawn or cold-rolled material is usually formed without removing this decarburized surface, it will carry the same defect. Turned or ground stock, such as shaft-

*Machine Design, Sept., 1942, Page 73.

ing or drill rod, is customarily supplied with this material removed. Parts forged from bar stock will similarly carry the defect, and add a bit of their own from reheating and forging operations.

While surfaces which are desired hard on forged or hot-rolled parts usually are machined, those on cold-rolled parts frequently are not. The temptation to use cold-rolled stock to size where possible, for economy's sake, must be resisted if the parts are to be heat treated (without surface carburization, of course) for surface hardness. A characteristic failure due to ignoring this factor is shown in *Fig.* 79, and the "decarbed" surface in *Fig.* 80. This piece should have been made from at least 1/16 inch heavier material to insure proper hardness of the working surface. Decarb can be expected to run from a few thousandths to .015-inch or more, on sizes up to two or three inches, and even more on heavier material.

It may not always be necessary, however, to remove this material. A case at point is the practice on leaf springs for railroad stock, using up to ⅜-inch thick, .90 to 1.05 per cent carbon, hot-rolled, oil-quenched steel in the as-rolled condition. Since these parts are stressed to as high as 100,000 pounds per square inch it would appear that failure from this could be expected. However, the range of stress on these parts is low, the average being 85 to 90 per cent of the maximum, so that the loading is close to "static". The outside surface under this circumstance probably yields a little to accommodate itself to the overstress. It should be noted that if the stress range were greater (not the maximum stress) so that fatigue became a problem, failure could be expected.

While the ills and defects to which commercial carbon steels are subject are many and varied, the control exercised by the modern reputable producer is such that the bulk of these troubles have become infrequent. Recognition of this should result in some relaxation of specification requirements to the aid of the war effort. At the same time, the possibilities and extent of these troubles cannot be entirely ignored and, on certain highly stressed and functionally important parts, careful control should be exercised.

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Precise Control Enhances Machine Performance

(*Continued from Page* 134)

in conjunction with an amplidyne exciter. This controls the main generator field excitation in response to a signal indication obtained from an electronic composing amplifier.

Indication of the speed is supplied by a pilot generator of the permanent-magnet type which is driven from the lineshaft of the machine. Voltage of this pilot generator or a portion of it is balanced against a voltage standard in the composing amplifier. The difference controls the excitation of the amplidyne to maintain the proper speed of the machine.

Current Held Within Limits

In addition to the main requirement of speed control, the current is held within definite limits during acceleration or retardation, *Fig.* 5. In starting the drive, the line contactor is closed and the current rises immediately to the limiting value slightly above full load. The drive accelerates at this current limit until the set speed is reached, when the current drops to the normal steady-state value required by the load.

When a change in speed is required, the operator moves the pilot-generator calibrating rheostat. Should this require an increase in speed, the current will be held at the upper current limit until the new speed is reached. Should the change be a decrease, the current will decrease to the point where the reverse-current limit control becomes effective. The drive will then slow down until the new speed is reached, when the current will again be stabilized at the value required to maintain constant speed for the load.

Such a system of control is applicable in many places, particularly where the inertia of the mechanical system is large and considerable time is required to accelerate from one speed to another. It can be employed, in brief, wherever an electrical or mechanical signal, no matter how small, can be utilized in effecting improved machine performance or faster production.

Colors Are Insulators!

BECAUSE colors absorb and reflect heat rays as well as light rays, they are practical and efficient "insulators" to control temperature and minimize the evaporation of certain liquids. According to the Color Research Laboratory of the Eagle Printing Co., white is the best color to repel heat and black the poorest. The hold of a white ship in the tropics will be at least ten degrees cooler than the hold of a black ship.

In a study of gasoline storage tanks the U. S. Bureau of Mines found that a red tank had an evaporation loss of 3.54 per cent over four and one-half months as against 1.4 per cent for white. Radiators in white and light colors also were found to be about 17 per cent more efficient than those painted black or bronze.

Compressed Air Saves Materials

(*Continued from Page* 146)

tioned which produce a high rate of insulation build-up between the interrupting contacts during current zero.

When the arc goes out at or near current zero, the insulating properties within the arcing zone are quickly reestablished and any reignition of the arc tends to take place between the points marked initial arc, where the air is still substantially under compression. Air is a good insulator and its insulation properties are greatly increased when the air is compressed. Consequently, the swiftly flowing compressed air amounts to a wedge of high insulation properties filling the zone of probable arc reignition and, therefore, a comparatively short contact separation (such as will provide maximum air blast efficiency) is sufficient to prevent reignition of the arc after the first current zero.

Simultaneously with the admission of air to the arc interrupting chambers, a small port permits air pressure to build up above a piston P_2 which is connected by linkage to a movable isolating contact. The build-up of pressure is so regulated that the piston will be forced down, opening the isolating contact to the position shown by dotted lines as soon as the arc interruption is completed and current flow has ceased.

Air and Spring Pressure Close Main Valve

Opening of the isolating contact provides a permanent opening of the circuit and, immediately after these contacts open, auxiliary controls act to cut off the air supply to the main valve piston. This results in closing of the main valve due to the spring pressure and the air pressure remaining in the tank; air pressure in the contact chamber falls and the arcing contact is closed by its spring. The circuit through the breaker remains broken due to the open position of isolating contacts. Closing of the circuit is achieved by pneumatic closing of the isolating contacts, through a closing valve and its piston P_3.

One of the most important features of this design is its contact maintenance cost as compared to other types of circuit breakers. It has been computed that, on the average, for every arcing contact replacement in an air-blast circuit breaker the conventional circuit breaker would require sixteen. Tests have proved that the times required to remove and replace the arcing contacts for each type of breaker are approximately thirty minutes for the air-blast breaker shown in *Fig.* 1 and 3¾ hours for the equivalent conventional circuit breaker. Hence, for every arcing contact maintenance dollar spent on the air-blast circuit breaker, \$88 would be spent on the conventional circuit breaker when operating on the same interrupting duty. This difference in maintenance cost becomes all the more important when it is considered that these arcing contacts are composed mainly of copper, a vital material.

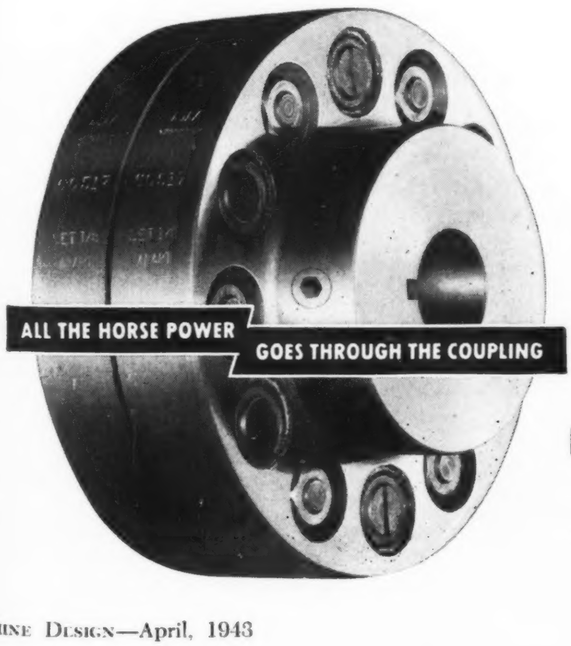
In *Fig.* 4 are shown the weight characteristics for various types and sizes of air-blast circuit breakers as compared to conventional oil circuit breakers. The lower weight is due mainly to reduction in the amount of steel used and to elimination of oil. Lower weight makes for easier handling during installation. The supporting means for the breakers can also be less robust, conserving steel.

Try to hold two pencils in perfect end-to-end alignment without touching each other, while you count ten!

Even if you brace your hands, wrists or arms as solidly as you can, you will quickly see why Ajax FLEXIBLE Couplings are essential to protect direct-connected machines from unavoidable mis-alignment.

Remember, too, that you are making this test with pencils weighing only an ounce or two . . . instead of costly machines driven twenty-four hours a day at high speeds by plenty of horsepower!

Manufacturing executives, design engineers, plant superintendents, and maintenance men are invited to write for the Inside Story of Ajax Flexible Couplings.



AJAX

FLEXIBLE COUPLING CO.
WESTFIELD, N. Y.
Incorporated 1920

Flat Belt Drives as Integral Parts

(*Concluded from Page* 127)

multiple-ply belt may wear out more quickly than a single-ply due to the higher bending stresses in the thicker belt. New tannages have greatly improved the flexibility of the belts. Leather belt drives have been standardized by the American Leather Belting association and the published tables offer the designer a wide selection from which to choose an appropriate drive.

For extremely high speeds selection is not so simple and the best drive must be worked out by the designer in cooperation with a belting manufacturer experienced in such drives. It goes without saying that this should be done in the early stages of design. Although the simple belt theory presented in most textbooks indicates a rapid falling-off in transmitted horsepower due to centrifugal force, practical experience shows that the effect is less drastic, particularly with belts which are not too elastic. Endless woven belts which combine light weight, high traction and minimum stretch with uniform thickness and flexibility are successfully run at speeds approaching 20,000 feet per minute. Such belts are run with fixed centers and relatively low initial tension. In designing high-speed fixed-center drives it is important to allow sufficient take-up for adjusting tension, 6 to 8 per cent of the center distance being a good rule.

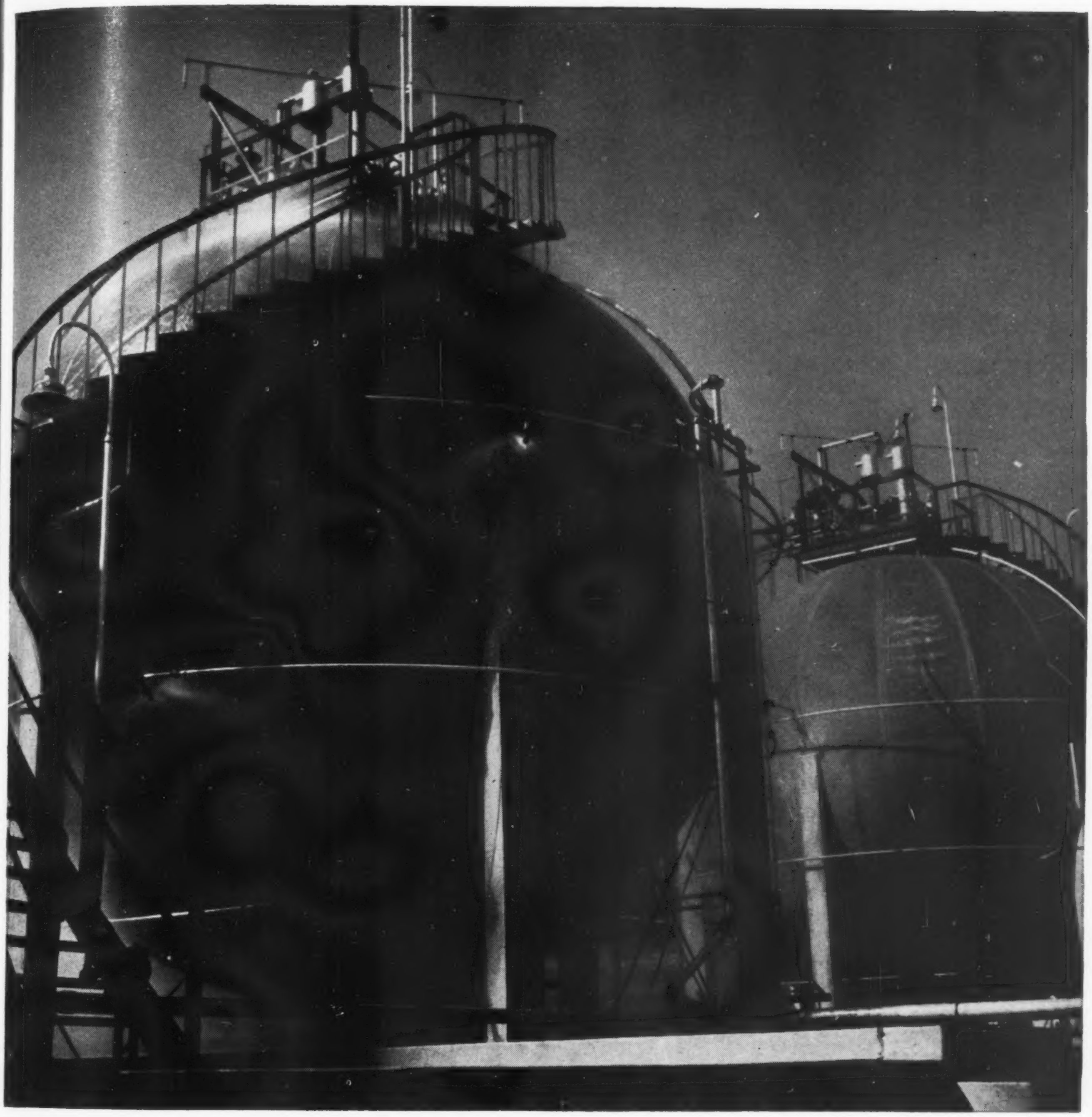
Friction Coefficient Can Be Controlled

While the majority of woven belts are rubber-impregnated to increase the coefficient of friction, there are cases where low friction is desired so that the belt can function as a safety-slip clutch. High-speed multiple drill presses are an example. Slippage is attained by special treatment or by leaving the belt untreated.

Pulley material recommended for short-center drives include wood and paper. Using paper a coefficient of friction at least 20 per cent higher than with steel or cast iron can be expected, while wood pulleys have friction characteristics between those of paper and metal.

Although built-in short-center belt drives are comparatively new, general-purpose drives of this type have so far used some 300,000 pivoted motor bases. Inherent conservatism may be responsible for the refusal of some designers to incorporate such drives in original designs; failure to appreciate the engineering development back of the modern controlled-tension drive undoubtedly has caused others to overlook its possibilities. Perhaps all that is needed is a reminder that "Any resemblance between the drives discussed in this article and the flapping belts of the old-style machine shop are purely coincidental!"

Cooperation of the following companies is gratefully acknowledged: The Akron Belting Co.; The American Pulley Co. (*Fig.* 5); Browning Manufacturing Co.; Chicago Belting Co.; Globe Woven Belting Co. Inc.; the B. F. Goodrich Co.; The Goodyear Tire & Rubber Co.; Graton & Knight Co.; E. F. Houghton & Co.; Ideal Commutator Dresser Co. (*Fig.* 2); J. E. Rhoads & Sons (*Fig.* 1); and The Rockwood Manufacturing Co.



AMERICA'S WAR PRODUCTION DEPENDS ON TANKS LIKE THESE

Take a good look at these huge spherical tanks. Chances are your hose, your belts, your packings may come from them or from others just like them.

These are used for storing butadiene in the first of the synthetic plants operated by U. S. Rubber Company . . . a second will soon be in production.

Having worked in the field of synthetic rubber since 1921 we know what uses each of the five basic types of synthetic rubber is best suited for . . . Neoprene, Buna-S, Buna-N, Butyl and Thiokol . . . U. S. Rubber uses all five types . . . knows which one to select for the performance required . . . and how to compound the specific synthetic rubber for the specific task. This experience is important to you.

Our booklet on synthetic rubber will give you much valuable information. Send for your copy.

Mechanical Goods Division

UNITED STATES RUBBER COMPANY

ROCKEFELLER CENTER • NEW YORK

ASSETS to a BOOKCASE

Introduction to Aircraft Design

By Thomas P. Faulconer, director of education, Consolidated Aircraft Corp.; published by McGraw-Hill Book Co., Inc, New York; 273 pages, 6 by 9 inches, clothbound; available through Machine Design, *$2.75 postpaid.*

Unusual scope of this book gives it particular value to engineers experienced in other fields who need specific information on the many phases of aeronautical engineering. Knowledge of engineering fundamentals being assumed, every aspect of airplane design is discussed in a concise but thorough and practical manner without the necessity of stopping at intervals to derive equations.

Following an extensive chapter on preliminary design, including basic aerodynamics, subjects are grouped according to their place in the organization of the engineering department. Thus the second chapter, on engine installation, discusses that part of airplane design which is the chief concern of the power plant group. Other branches so discussed are: Control surface design, wing structure, fixed equipment, hull design, beaching and landing gear design, electrical equipment, aircraft hydraulics, structural design, modern aircraft materials and weight engineering. A short chapter follows on engineering contract administration and the book concludes with a lengthy chapter on testing and research, written by K. R. Jackman, chief test engineer of the Consolidated Aircraft Corp.

Illustrated by line drawings, perspective sketches and photographs, the book is well organized and should prove equally valuable for study and for reference.

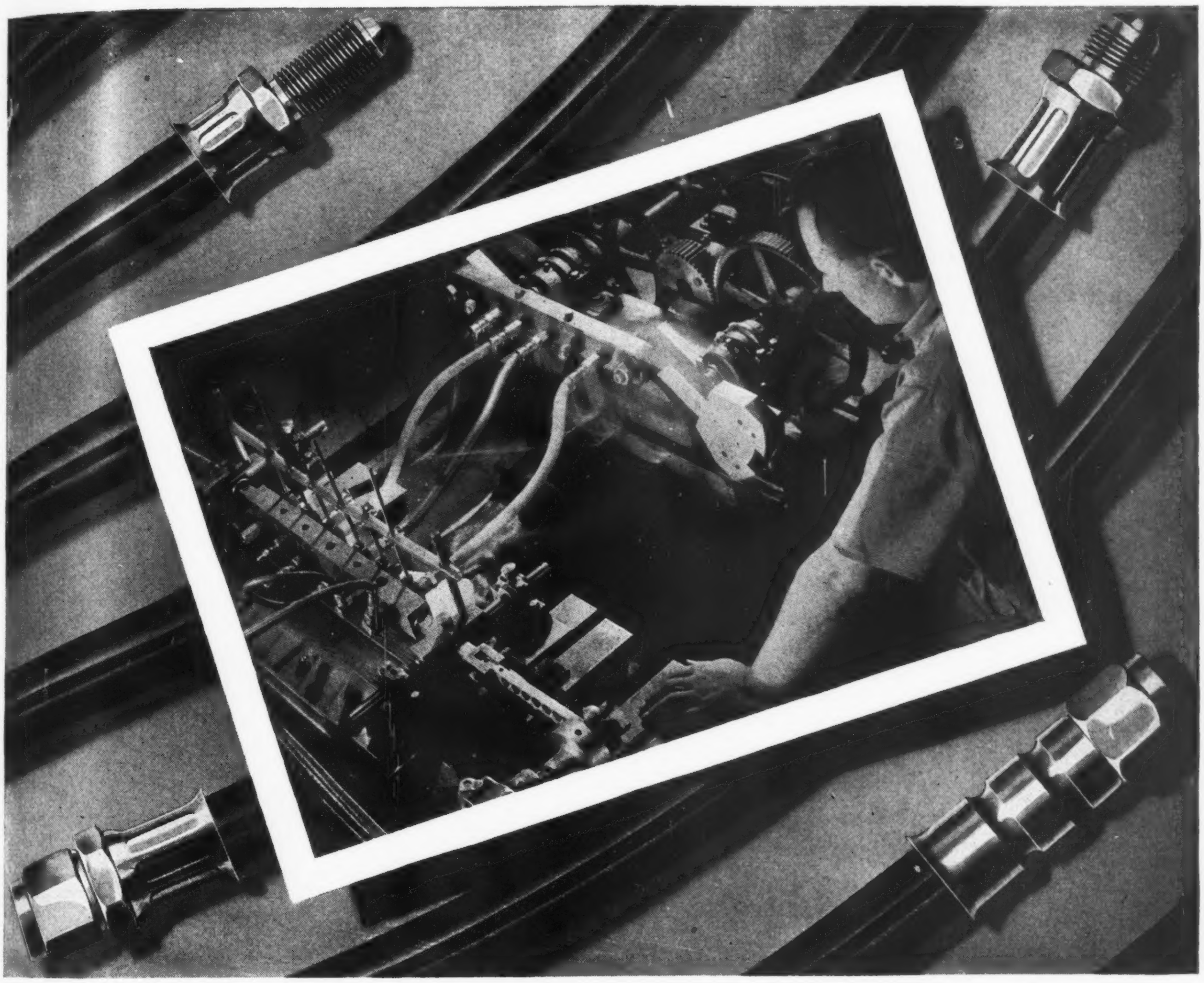
□ □ □

Surface Finish

By George Schlesinger, director of research, The Institution of Production Engineers; American edition published by The American Society of Mechanical Engineers, New York; 231 pages, 5½ by 8¾ inches, clothbound; available through Machine Design, *$3.52 postpaid.*

Dealing primarily with the measurement of surface finish as a preliminary to the establishment of standards of measurement, this report is a comprehensive review of the subject. Data are presented covering the surface quality of more than four hundred finished surfaces on a large number of sample machine parts, instrument parts, gages, etc. Measurements of the depth of surface irregularities using various instruments are compared.

Instruments used for these measurements are described, as also are the various methods of qualitative analysis (estimation and comparison). Other chapters included cover the influence of the scratching action of the stylus of tracer instruments, classification of surfaces without measurement, quantitative photomicrography, dimension and surface roughness of gages, and investigation of surface roughness in the U. S. A. Because national standards are about to be set up for specification, designation, and measurement of surface finish, the book is of timely interest to designers.



"I'm wasting my time."

SAID THE TORTURE MACHINE

If machines could talk, there's one in our laboratories that would say just that.

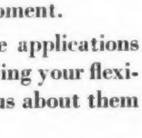
Designed and built by Resistoflex technicians, it twists, flexes, pulls and vibrates hose assemblies while they carry fluid at various temperatures and under a wide range of pressures. Years of use are measured in minutes. Yet Resistoflex lines stay in service hour after hour.

Today, the claims made by the torture machine are being backed up by the performance of hundreds of thousands of Resistoflex assemblies on military airplanes and trucks as well as on a wide variety of industrial equipment.

Technical data on these applications may be of vast help in solving your flexible hose problems. Write us about them today . . . or

SEND FOR CATALOG

Write for the Resistoflex Industrial Catalog. On your company stationery, please.



RESISTOFLEX FEATURES:

STRONGER—Resistoflex lines outpoint all similar lines in tensile strength.

PERMANENT, FULL FLOW — Chemically inert, glass-smooth lining provides permanent free flow—eliminates turbulence and skin friction.

NON-CLOGGING—Resistoflex hoses do not gum, never clog hydraulic or lubrication systems, diesel injector nozzles or other fine orifices.

FLEXIBLE, VIBRATION PROOF—Tens of thousands of simultaneous flexings and twistings have no effect on Resistoflex lines.

LOW AND MEDIUM PRESSURE, HYDRAULIC AND VACUUM HOSE ASSEMBLIES MANOMETER TUBING, DIPPED AND MOLDED SPECIALTIES.

RESISTOFLEX

RESISTOFLEX CORPORATION, BELLEVILLE, NEW JERSEY

Blower Design

(*Continued from Page* 147)

by the continuous edges of the helical threads on the gate rotor and the sides of the gate rotor described by the crests of the threads on the main rotor.

If a housing is pictured as enclosing the rotors shown in the illustration, a clearly defined pocket will be apparent on the side of the observer. If the main rotor were turned counterclockwise when looked at from the left, the pocket would be seen to advance from left to right. In this event the discharge connection would be adjacent to the timing gear end on the side toward the observer. If the rotation were reversed the same port would become an intake port. In installations where the direction of air flow must remain constant regardless of direction of rotation, as would be the case where the blower is used in conjunction with a reversible engine, a reversing valve has been developed which is built directly into the blower case. Because of the special shape of this valve full size streamline air flow passages are maintained in both directions.

A rotor speed ratio of two to one is used. There are several reasons for this choice. It so happens that this ratio gives the maximum capacity for a given size of bulk. Torsional vibration difficulties, even at the highest speeds, are relieved to a considerable extent because one of the rotors is comparatively light and operates at only half the main rotor speed. This feature is of particular importance when the blower is driven by a prime rotor with severe torsional impulses, such as an internal combustion engine.

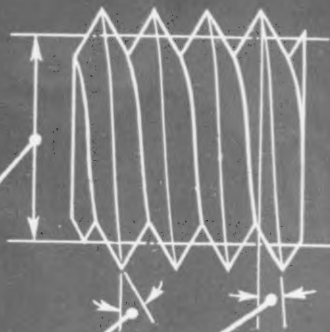
Gate Rotor Lightly Loaded

In this particular blower the angle and thickness of the threads is such that practically all the work is done by the main rotor, the gate rotor performing the function of a valve. Since the area of the groove in the gate rotor exposed to the compression pressure is approximately equal on both sides of the center, the timing gears are relieved of practically all load. However, it has been found necessary to maintain a small load, about ten per cent of the total power, on the timing gears; otherwise they tend to chatter.

In order to pump, the abutments must have some lead, as all screws have, which means that two rotors with opposite helical angles will not mate properly without there being clearance so the threads can roll into and out of mesh. Thus it is apparent they are not self-sealing and that other means must be employed. In the present design the ends of the case prevent the back flow of the fluid being pumped.

Keeping oil out of the air chamber has always been a difficult problem in blower design. The trouble is that there is vacuum on one side of the rotors and pressure on the other. The pressure blows through the seals into the gear case and builds up a pressure which causes the oil to leak back through the seals on the suction side. The vacuum on the suction side of the blower aggravates this condition. Experiments were conducted on all known methods of mechanical sealing and none have been found entirely effective when using a high intake vacuum. The

Check these quickly, accurately . .



with VARD precision Snap Gages

If your pitch diameter is right; if your thread form angle is accurate; if your lead is correct—a VARD Snap Gage will quickly pass the threads through the GO rolls and stop them at the NO GO rolls. In one easy movement you can see and feel the accuracy of your threads. You can check your work while it is still in the machine. You can gage threads flush against a working shoulder.

The VARD Snap Gage has an improved type of frame with convenient machine pads for use in a vise.

The accurate rolls are ground from highest quality tool steel and are adjustable to compensate for wear. We make these gages in a full range of sizes and in all Standard thread forms, English, Metric and right and left hand threads in all classes of fit.

VARD INC.

Special Taps • Plain Tapered Ring Gages • Thread & Plug Gages • Bench Model External Comparators • Precision Ground Optical Lenses & Filters • Aircraft Geared Parts • Aircraft Hydraulics

PASADENA, CALIFORNIA, U. S. A.

present blower design solves this problem in a simple manner. There is a narrow groove in a bronze sealing member around the shaft, between the bearing and air chamber. This groove is vented to the atmosphere and thus breaks the pressure or vacuum before it reaches the bearings and gears. There is continuously a small amount of air entering or leaving these vents and the method has been found to be highly effective.

The case is made of aluminum with the reversing valve chamber and passages cast integral. For an 8000-cubic feet per minute blower, the case and valve chamber weigh about 1000 pounds. One of the case ends is also cast integral with the case and the bearing bores bored at the same setting as the rotor bores. The loose case ends are made in two parts and are designed with a re-entering diameter so that the bearings are positively centrally located at both ends. This design also helps prevent distortion of the case and centers the rotors so that it is almost impossible for them to rub on their periphery.

Materials Affect Clearance

Blower clearances always plague the designer and complicate the choice of materials. Since the blower was designed for marine use, it has been necessary to use aluminum for the housing because of the weight involved. However, it was felt unsafe to use aluminum also for the rotors because of their tendency to seize. Cast iron could not be used because of its weight and because of the stresses due to centrifugal force. The shape of the rotors is such that fabrication from welded steel is almost impossible. So it was decided to use a high grade aluminum bronze. This material flows readily in thin sections and has the tensile strength of mild steel. It is ductile and machines easily. The greatest gain, however, is in the rate of expansion. Since the rotors in a blower are always hotter than the case the rotors expand the most and decrease the clearances if like materials are used. However, since bronze expands only about three-fourths as much as aluminum the internal clearances remain about the same. Further, if a bronze rotor should slightly rub an aluminum case it will tend to wear a clearance rather than seize as aluminum rotors would do. The bronze rotors are supposed to be more stable as regards changes in size and shape after long periods of use. These rotors are thinner than it would be possible to make aluminum rotors, weigh about twice as much and cost about the same.

When the blower is driven by a diesel engine, due to torsional impulses a heavy rotor would be a disadvantage if the blower were rigidly coupled. However, if a correctly designed resilient drive is used, the heavy rotor becomes an advantage. The ideal situation is a resilient drive, a heavy main rotor which receives the drive and neutralizes the impulses, and a light gate rotor.

When tested in comparison with a specially built spiral three-lobe blower also designed for marine engines, the new blower showed a volumetric efficiency five per cent higher and overall adiabatic efficiency four to nine per cent higher, the difference being most pronounced as pressure and speed increased. Intake noises without muffler were four to six decibels less and discharge noises seven to eleven decibels less. Noise did not noticeably increase as the pressure increased.

USINESS AND SALES BRIEFS

PROMOTION of William J. McIlvane from general manager of sales to vice president in charge of sales has been made by Copperweld Steel Co., Glassport, Pa.

♦

Removal of its research and development laboratories to new quarters adjoining the general offices at 314 West First street, Dayton, has been made by New Wrinkle Inc. This change has been necessitated to accommodate the enlarged staff and research facilities.

♦

Howard M. Givens Jr., manager of tool steel sales for Allegheny Ludlum Steel Corp., Brackenridge, Pa., will make his headquarters at the corporation's offices at Dunkirk, N. Y. Prior to his move to Dunkirk, Mr. Givens had been located at the Pittsburgh office.

♦

Announcement has been made by Acro Electric Co. of the removal of its offices and manufacturing facilities to a new plant at 1305 Superior avenue, Cleveland. The expanded facilities will permit acceptance of greatly increased orders.

♦

Cleveland Graphite Bronze Co., Cleveland, has promoted L. W. Christenson from assistant sales manager to sales manager of the company.

♦

Recently the Federal-Mogul Corp., Detroit, announced the election of Edwin Olney Jones as vice president of the company. Mr. Jones continues as sales manager.

♦

Appointment of Thomas C. Finnell as manager of the industrial department in the eastern district has been made by Westinghouse Electric & Mfg. Co. Succeeding C. W. Miller, who has been named manager of the application department of the company's radio division at Baltimore, Mr. Finnell in his new position will supervise the supplying of electrical equipment to war industries throughout the states of New York and Northern New Jersey.

♦

With headquarters at 727 Grant street, Akron, O., George R. Atkins will act as manager of the branch sales office and factory of The Bristol Co., Waterbury, Conn. He formerly was connected with the Pittsburgh district office.

♦

An announcement has been made by the General Electric Co. to the effect that its Radio, Television and Electronics department will be known as the Electronics department in the future.

♦

Recently The Peerless Electric Co., Warren, O., celebrated its fiftieth anniversary in the electrical industry. The firm was founded in 1893 by Elmer W. Gilmer as The Warren Electric & Specialty Co. He also founded the Economy Lamp Co., Colonial Fan & Motor Co., and Colonial Electric Co., which were incorporated into The Peerless Electric Co. in 1902.

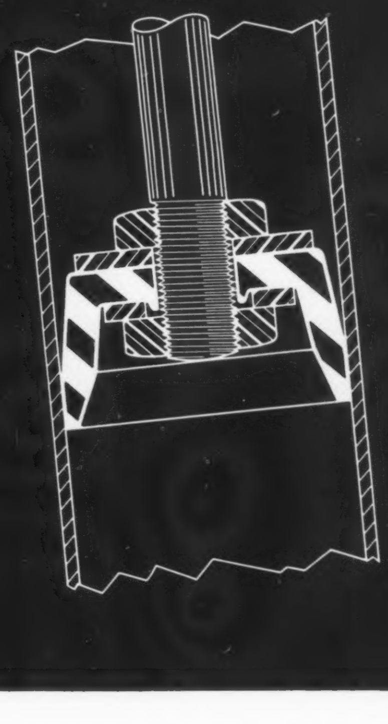
♦

Associated with the company since 1933, B. H. Quackenbush has been appointed assistant sales manager of Foote Bros.

CASE HISTORY No. 200

PACKINGS

PROBLEM: **To find a piston packing—impervious to hydraulic fluid—which would not swell, stick, or shrink.**



This non-sticking, non-shrinking piston packing is molded of one of Armstrong's Synthetic Rubber Compositions for use in hydraulic fluid.

THE designers of a hydraulically operated mechanism for military use had trouble finding a piston packing which would perform perfectly every time. Of the various packings they tried, some swelled and stuck to the cylinder . . . some shrank and by-passed the fluid . . . others deteriorated.

Solution

The problem was turned over to Armstrong Cork Company's sealing specialists, who designed a suitable packing and submitted samples molded of one of Armstrong's Synthetic Rubber Compositions. Thorough testing proved these pieces completely satisfactory, and the Armstrong cup was adopted. Armstrong has not only the *right material*—but also the manufacturing "know how" to turn out precision-molded packings in quantity . . . *fast.*

Rolls, Gaskets, Special Shapes

To get unbiased recommendations on *your* packing, sealing, or gasket problem, send it to Armstrong. There are more than fifty specialized sealing materials in the Armstrong Line. See list of general types below. Compositions with practically any desired physical properties are available in rolls, sheets, cut gaskets, and molded or extruded shapes. Write for the 8-page catalog describing them. Address Armstrong Cork Company, Industrial Division, 5104 Arch Street, Lancaster, Pennsylvania.

ARMSTRONG'S
GASKETS · SEALS · PACKINGS

Synthetic Rubbers • Cork-and-Synthetic-Rubber Compositions*
Cork Compositions • Cork-and-Rubber Compositions
Fiber Sheet Packings • Rag Felt Papers • Natural Cork

*FORMERLY "CORPRENE"

Gear & Machine Corp., Chicago. He will continue to handle contract sales and in addition will supervise activities of the priority department and the sales department under OPA price regulations.

♦

Located at Wooster Pike and Mariemont avenue, Cincinnati, is the new building of The Cincinnati Gear Co, which contains twice the floor space the company had in its old location. The output, it is expected, will be increased 50 per cent due to the additional space and machine tools.

♦

Succeeding Dr. H. A. Jones, E. H. Fritschel has been placed in charge of sales of industrial electronic tubes, in addition to being responsible for the sale of radio transmitter tubes, Radio, Television and Electronics department, General Electric Co., Schenectady, N. Y.

♦

In the Dayton sales office of Republic Steel Corp. since 1936, D. A. Shardelow has been appointed district sales manager for the company at Indianapolis.

♦

Wilfred C. Shattuck has returned to Wickwire Spencer Steel Co., New York, as wire sales manager. He had been connected with the company until 1940 when he left to join John A. Roebling's Sons Co.

♦

Formerly manager of distributor sales, industrial products division of B. F. Goodrich Co., Chester F. Conner has joined the staff of advisers on mechanical rubber goods in the Office of Rubber Director, War Production Board, Washington.

♦

According to an announcement released by the By-Products Steel Corp., Coatesville, Pa., Harry R. Meyer is now general manager of sales. He formerly was manager of direct sales for the Lukens Steel Co.

♦

Appointment of Carl J. Meister as manager of sales of Atlas Metal Stamping and Atlas Tool & Designing Companies, Philadelphia, has been announced. He formerly was field sales manager for the Allen Mfg. Co. and is well known to the machine tool industry.

♦

In his new post as electronic control specialist for Westinghouse Electric & Mfg. Co. in the Los Angeles area, John J. Fiske will represent the company in matters having to do with electronic control devices for resistance welding equipment.

♦

With headquarters at 1719 Comer building, Birmingham, Ala., A. F. Dobbrodt has been named southern district manager for Carboloy Co. Inc., Detroit. He has been associated with the company since 1929 and has been active in design, sales and servicing of the company's cemented carbide tools.

♦

Since 1937 assistant manager of sales, Carbon Bar division, Republic Steel Corp., Cleveland, R. W. Hull has been appointed manager of sales of that division, replacing W. F. Vosmer who is now in Washington as manager of the War Production board's hot-rolled carbon bars and semifinished units. J. V. Burley, manager of sales of the sheet and strip division, has been appointed general manager of sales, Steel and Tubes division. John W. Carpenter, assistant manager of sales, sheet and strip division, has been named acting manager of that division.

HOW SHEET MILL "DISCOVERED" 11 MUCH-NEEDED MEN

—and what Hele-Shaw Fluid Power Engineers had to do with it

In a sheet mill, whose name we can't quote, men were laboriously reducing billets to sheets. Fourteen men were required to "manipulate" the billet and sheet in its journey, fourteen men needed elsewhere in the mill for essential war work.

This mill had used Fluid Power and had an idea Hele-Shaw Fluid Power Engineers might help them.

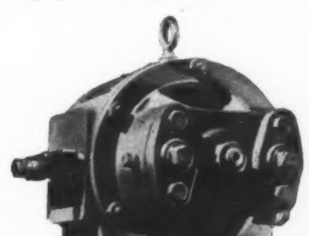
Before our engineers left they had: 1. schemed a hydraulic mechanism (powered by a Hele-Shaw pump, and functioning through valves and cylinders) which duplicated nearly all of the hand operations, and 2. whittled the number of men required from 14 to 3. One man now starts the billet through the rolls, one removes the finished sheet, and the third controls all intervening operations by means of a centralized push button control.

Saving labor is not always the reason for trying Fluid Power, and may not be yours. If you want to improve a product or process, or simplify the control or operation of a machine in your post-war planning, Fluid Power and Hele-Shaw engineers may be able to help you. Why not find out?

THE

Hele-Shaw

Fluid Power Pump



OTHER A-E-CO PRODUCTS: **TAYLOR STOKERS, MARINE DECK AUXILIARIES, LO-HED HOISTS**

ÆCO

AMERICAN ENGINEERING COMPANY

2502 ARAMINGO AVENUE • PHILADELPHIA, PA.

MEETINGS AND EXPOSITIONS

April 7-10—

Electrochemical Society. Meeting to be held in Pittsburgh. Colin G. Fink, 3000 Broadway, New York, is secretary.

April 9—

Society of Chemical Industry. Rubber and Plastics division, Montreal section meeting to be held at McGill university, Montreal, Canada. Cyril S. Kimball, 305 Washington street, Brooklyn, N. Y., is secretary of the society.

April 9-10—

Midwest Power Conference. Meeting to be held in Chicago. Additional information may be obtained from the Illinois Institute of Technology, Chicago.

April 12-16—

American Chemical Society. Spring meeting to be held at the Book Cadillac hotel, Detroit. Dr. Charles L. Parsons, 1155 Sixteenth street, Washington, D. C., is secretary.

April 18—

American Ceramic Society Inc. Forty-fifth annual meeting to be held at the William Penn hotel, Pittsburgh. Ross C. Purdy, 2525 North High street, Columbus, O., is general secretary.

April 20-23—

National Electrical Manufacturers' association. Spring meeting to be held at the Palmer House, Chicago. W. J. Donald, 155 East Forty-fourth street, New York, is managing director.

April 26-28—

American Society of Mechanical Engineers. Spring meeting to be held in Davenport, Iowa. C. E. Davies, 29 West Thirty-ninth street, New York, is secretary.

April 28-30—

American Foundrymen's association. Forty-seventh annual meeting to be held at Hotels Jefferson and Statler, St. Louis. R. E. Kennedy, 222 West Adams street, Chicago, is secretary.

May 10—

Association of Iron and Steel Engineers. Annual spring conference to be held at the William Penn hotel, Pittsburgh. Brent Wiley, Empire building, Pittsburgh, is managing director.

May 10--11—

American Institute of Chemical Engineers. Meeting to be held at the Waldorf-Astoria hotel, New York. S. L. Tyler, 50 East Forty-first street, New York, is executive secretary.

May 13-14—

Society of the Plastics Industry. Annual meeting to be held at the Edgewater Beach hotel, Chicago. W. T. Cruse, 295 Madison avenue, New York, is executive vice president.

May 17-18—

American Mining Congress. Coal Mine War conference to be held in Cincinnati. Julian D. Conover, 309 Munsey building, Washington, D. C., is secretary.

June 28-July 2—

American Society for Testing Materials. Annual meeting to be held at the William Penn hotel, Pittsburgh. R. E. Hess, 260 South Broad street, Philadelphia, is assistant secretary.